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Campbell, John H., 531 Vine st. 2d
Carll, M. F., Dentist, 806 N. 11th st 2d
Carnell, John, Contractor, 2114 N 6th st 2d
Carpenter, A. E., Mfr., 215 S. Front st C
Carpenter, Jas. H., Lawyer, Camden, N. J. C
Carr, George W. L
Carrick, Wm. C., Baker, 1903 Market st C
Carter, John E., Chemist, 329 S. 12th st C
Cartwright Henry, Engineer, 2107 Green st 1st
Cartwright, Henry R. 1st
Carver, Wm. Y., Clerk, 325 Walnut st C
Cassin, Isaac S., Engineer, 1404 N. 12th st L

Cattell, Samuel W., Painter, House of Correction, 23d Ward L
Cawley, Samuel B., Bricklayer, 1413 N. 13th st L
Chabot, Cyprian, Machinist, 1157 S. 15th st L
Chambers, A. G., Grocer, N. E. cor. 5th and Pine C
Chambers, Cyrus, Jr., Machinist and Founder, 52d st. below Lancaster av C
Chandler, Jas B., Printer, 308 Chestnut st L
Chandler, Morris, Student, 25 N 7th st C
Chandler, Wm. P., 2110 Spruce st C
Charman, Chas H. J., Lawyer, 619 Walnut st C
Chase, F. B., Machinist, 1323 Spring Garden st C
Chase, Jas A. 1st
Chase, Pliny E., Secretary, Haverford Coll., Pa. 2d
Chatelet, Andrew, Engraver, 6 Shoemaker st C
Cheeseman, E. S., 1528 Pine st C
Cheney, Edward L., Furnace and Range, 275 S 3d st 2d
Cheney, Luther L, Machinist, Downingtown, Pa C
Cheney, Waldron J., Silicates, 3047 Chestnut st L
Cheney, Wm. A., Conveyancer, 15 S 7th st 2d
Chesterman, Edwin. Publisher, 927 Filbert st C
Chew, Sinnickson, Editor, Front and Market, Camden, N. J. C
Child, John M., Teacher, 634 Race st C
Child, Thos. T., 824 N. 2d st L
Childs, Geo. W., Publisher, 6th and Chestnut L
Christy, Daniel, Pattern-maker, 124 Queen st L
Christy, James, 266 N. 7th st L
Churchman, Chas. W. L
Claghorn, J. Raymond, 222 W. Logan sq 1st
Clark, John G. L
Clark, J. Ross, Printer, 230 Dock st L
Clark, Robert, 251 S. 8th st 2d
Clark, Wm. M., Engraver, 400 Chestnut st L
Clarke, Thos. C., C. E, New York City 2d
Clarke, Wm. H. L
Clarkson, Edward, Engraver. L
Clarkson, Michael, Bookkeeper, N. E. Front and Girard av C
Claxton, Edmund, 624 Market st 1st
Cleeman, Thos. M., C. E., 343 S. 21st st C
Close, Chas. W., Conveyancer, 331 Reed st 1st
Close, Edwin A., 333 Reed st 2d
Close, Franklin N., Iron Broker, 331 Reed st 2d
Close, Henry S., 333 Reed st 2d
Clothier, Caleb, Bricklayer, 1630 Filbert st L
Clothier, C. F, Manufacturer, 22 N. Del. av C
Clothier, James, Manufacturer, 816 E York av L
Clunn, Frank, Salesman, 617 Chestnut st C
Clunn, Frank, Salesman, 617 Chestnut st C
Cochrane, Henry, Student, 1817 Walnut C
Code, Theophilus, Meter-maker. L
Codman, John E., Draughtsman, Water Dept. C
Coleman, Ezra. L
Collins, Alfred M., Merchant, 1518 Locust st L
Collins, Edward, Architect, 410 Walnut st C
Collins, Henry H., Cards, 103 S 21st 2d
Collins, James, Physician, 538 Marshall st C
Collins, Jos. H. Lumber Dealer, 1221 N. 8th st C
Collins, Jos. H., Jr., Machinist, 22 and 24 N. 4th C
Collins, T. Earl, Draughtsman, 500 N. Broad st C
Colton, O. B., C. E., 2009 Wallace st C
Comstock, George S. Engineer, 15th and Wood. C
Conard, Thos. P., Iron Founder, 216 N. 32d st C
Conarroe, George W., Artist, 334 Sth 16th L
Conde, C. A., M. E, 1308 Ridge av C
Cone, Henry D., Housatonic, Mass. L
Conrad, Isaac H. M. D., 215 Vine st 2d
Conrad, Osborne, Watchmaker, 252 N. 5th st 2d
Constable, Howard, Engineer, 241 S. 18th st C
Converse, John H., 500 N. Broad st 1st
Cook, Wm. F., Carpenter, 1326 Franklin st C
Coombe, Thos. R, Apothecary, 3928 Market st C
Cooper, C. C., Clerk, 5581 Germantown av C
Cooper, David, Clerk, 410 Race st C
Cooper, Henry R., 1733 Filbert st 2d
Cooper, Jas. W., Cabinet-maker, 1706 Washington av 2d
Cooper, John H., Draughtsman, Front and Girard av C
Cooper, John L
Cooper, John L., Conveyancer, 5581 Germantown av 2d
Cooper, Jos. B., Jr., Carpenter, 21 N. 7th st C
Cooper, Wm. B., Student, 5581 Germantown av 2d
Cooper, Wm. S., Brass Founder, 15 N. 7th st C
Cope, Caleb, President, 718 Spruce st L
Cope, E. R., Paper Dealer, 26 S. 7th st C
Cope, John E., 230 S. 3d st 1st and L
Cope, Marmaduke C., Merchant, 1319 Filbert st L
Copper, John C., Tool Cutter, 15 S. 6th st L
Corlies, S. Fisher, Lawyer, 1717 Arch st L
Cornelius, Chas. E, Manufac., 1332 Chestnut st C
Cornelius, J. C., Manufac., 1332 Chestnut st C
Cornelius, R., Manuf., 821 Cherry st 1st and L
Cornish, Thos. E. Electrician, 1111 Chestnut st C
Couch, A. B, 21st and Callowhill sts 1st
Courtney, Geo. S., Furniture, Tuckerton, N. J. L
Cowden, M. A., 1424 N. 12th st 1st
Cowperthwaite, Emmor, Upholsterer, 1935 Mt Vernon st C
Cox, F., Ship Joiner, 326 E. Thompson st 2d
Cox, John L
Cox, J. Silgraves, Engineer L
Cox, Wm. P. Draughtsman, 206 N. 4th st C
Coxe, Brinton, Lawyer, 1711 Locust st C
Craig, George S. L
Craig, Jared, Printer, 333 Walnut st L
Craig, John G., Painter, 31 N. 7th st L
Craig, Temple L
Cramp, Chas. D., Ship Builder, 1356 Hanover st 1st
Cramp, Chas. H., Ship Builder, 1736 Spring Garden st 1st
Cramp, H. W., Clerk, 1700 Park av C
Cramp, Jacob C., Ship B'lder, Beach & Norris sts 1st
Cramp, Samuel H., Ship Builder, Beach and Norris sts 1st
Cramp, Theo., Ship Builder, Beach & Norris sts 1st
Cramp, W., Ship Builder, Beach & Norris sts 1st & L
Cramp, Wm. M., Ship Builder, Beach & Norris sts 1st
Crammer, Wm. C., Civil Eng., 1918 Christian st C

Crease, Alfred L
Crenshaw, N. B., 400 Chestnut st 2d
Cresson, Chas. C., Merchant, 1132 Girard st C
Cresson, Dr. Chas. M., 417 Walnut st L
Cresson, G. V., Machinist, 18th and Hamilton sts C
Cresson, James H., Merchant, 1206 Filbert st 1st
Cresson, Jos. Jr., 124 S. 22d st C
Crofut, Geo. W., Publisher L
Crosby, D. E., M. E., Millville, N. J. C
Cross, Geo. W., Iron Chests L
Crowell, Wm., Salesman, 713 Brown st C
Culbertson, Thomas, 1609 Somerset st L
Culp, Andrew J., Machinist, 1427 N 7th st C
Cunningham, Francis A., C. E., 817 Arch st C
Curtis, John, N. W. 17th and Cayuga sts L

Dallett, Thomas H., Soaps, Cheyney Station, Delaware co., Pa 2d
Darrach, Charles G., C.E., 100 N. 39th st C
Davis, Courtland H., 1631 Franklin st 1st
Davis, H. C., Penn Mines, Mich., 205 Walnut pl C
Davis, L. H., C.E., Riverton, N. J C
Davis, N. C., Clerk, P. R. R. Freight Office, Washington Avenue Wharf C
Davis, Wm. H., Merchant L
Davidson, Rob't B., Broker, 313½ Walnut st L
Dawson, Wm., Carpenter, 515 N. 10th st C
Dealy, Dennis F., Editor, 21 S. 7th C
Decker, Lizzie S., 1034 Race st 2d
Deitrich, Emile F L
Deitz, W. H., Plumber, 312 Dickinson st C
Delbert, Simon, Tallow, 1724 Arch st L
Delp, C. D., Insurance Agent, Norristown, Pa C
Desmond, Wm. C., Costumer, 917 Race st C
Deutz, A. Cornelius, Jeweler L
Devlin, Thos., Iron Foundry, 9th & Jefferson sts C
Dialogue, John H., Steam Ship Builder, Broadway and Pine sts., Camden, N. J 2d
Dick, Evan R 1st
Dick, Franklin 1st
Dickerman, Chas. F., Boots and Shoes, 1120 Wallace st C
Dietrichs, E. F., 422 Ludlow st L
Dillon, Eli, Plasterer, Ridge av and Green st L
Disston, Albert H., Saw Manfr., 1326 N. 15th 2d
Disston, Thomas S., Saw Maker, Tacony, Pa 2d
Dixon, E. S., Lawyer, 715 Walnut st 2d
Dixon, G. B., Furnaces and Ranges, 1330 Chestnut st 2d
Dixon, G. W., 39 S. Water st 2d
Dock, Clifford, Machinist, 904 N. Broad st 2d
Doll, George, Turner, 10 N. 6th st C
Donaldson, W. F., Printer, 26 S. 7th st C
Donohugh, Wm. J., Clerk, 723 Arch st C
Donovan, Daniel, 608 Market st 2d
Dougherty, James, Moulder, 13th and Buttonwood sts L
Douglas, J., Jr., Metallurgist, Phœnixville, Pa C
Dowler, Jacob, Coal Dealer, 645 N. 11th st C
Downing, Richard H., Iron, 1613 Race st L
Doyle, James, Builder, 911 Filbert st C
Draper, Edmund, Math. Inst. Maker, 226 Pear st L
Draper, Prof. John W L
Drayton, Wm. Heyward, Lawyer, 704 Walnut st L
Dreer, Ferdinand J., 1520 Spruce st L
Dresher, George B., 107 S. 3d st, 2d story C
Dripps, W. A., Engineer, 3405 Walnut st C
Drown, W. A., Jr., Umbrellas, 246 Market st C
Drysdale, T. M., Physician, 1531 Arch st C
Du Bois, Wm. E., Assayer, U. S. Mint C
Dubois, W. L., Treasurer, 421 Chestnut st 1st
Ducomb, John F., Book Binder, 27th S. 6th st L
Dudley, P. H., C. E., 27 West 9th st., N Y C
Dundore, Franklin, 519 N. 6th st 1st
Dundore, Nathan, 220 S. 4th st 1st
Dunglison, T. R., Physician, 814 N. 16th st C
Dunton, Joseph F., Merchant, 213 S. Front st C
Dunwoody, Chas., Merchant, 3266 Sansom st C
Dupuy, Chas. M., C. E., 4102 Spruce st C
Durang, Edwin F., Architect, 51 N. 6th st C
Durfee, W. F., Engineer, Atlantic Hotel, Bridgeport, Conn C
Dwight, E. P., Hyd. Engineer, 407 Library st., 2d story 2d
Dye, John H., Surveyor, Public Buildings, Broad and Market sts 2d
Dykeman, Geo. R., 43d and Oregon sts 1st

Eakin, Constant M L
Eastburn, George, Teacher, Broad st and Fairmount av C
Eastwick, A M., Machinist, 121 Walnut st L
Eavenson, A. T., Manufacturer, 2013 Vine st C
Eccles, J., Machinist, 2423 Lombard st 2d
Edgerton, N. H., 1221 Market st C
Edmunds, Henry R., Attorney at Law, 530 Locust st C
Ehlers, P., Engineer, Penn and Almond sts C
Eldridge, G. M., Lawyer, 708 Walnut st 2d
Elkinton, G. M., Tallow, 424 N. 4th st L
Elkinton, Jos. S., Manufacturer, 331 S. 5th st L
Ellis, Wm. H., Carpenter L
Eltonhead, W. B., Jeweler, 10th and Chestnut sts C
Elverson, J., Publisher, 8th and Locust sts C
Elwyn, Dr. Alfred, 1422 Walnut st L
Ely, Theo. N., C. E., Altoona, Pa C
Emerick, Jno. A., Foundry, 1056 to 1076 Beach st 2d
English, J. E., Plasterer L
Ennis, Prof. J., Principal L
Erben, Henry, Manuf'r, 2416 Spring Garden st C
Erben, P. C., 206 W. Logan Square L
Erker, Adolph P., Optician, 416 Olive st., St. Louis, Missouri C
Estlack, Chas. E., Bricklayer, 119 S. 18th st C
Estlack, Geo., Builder, 119 S. 18th st C
Estrada, R., Engineer, 1012 Passyunk av C
Evans, Chas., Machinist, 1011 Vine st L
Evans, Rob't C., Broker, 425 Cooper st., Camden, N. J C
Everett, Wm., Engineer, Rye, N. Y L

Fagerstrom, A. W., Machinist, Morrisville, Fauquier co., Va. C
Fahnestock, G. D., Clerk, 307 Walnut st C
Fairbanks, C. H., Printer L
Fairbanks, E., Manuf'r, St. Johnsbury, Vt. L
Farnum, John, Clerk, 1536 Pine st C
Faser, C., Frame Maker, 824 Arch st 2d
Faught, L. B., Superin'd't, 1220 N. 18th st 1st
Faulkener, Arthur, M.E., 3309 Hamilton st C
Fell, J. G., Coal, 303 Walnut st 1st
Fellows, Walter A., Geologist, 529 Preston st C
Fenton, Frank A., Manufacturer, 145 Race st C
Fenton, J. H., Manuf'r, 145 Race st C
Ferguson, J., Book-keeper, 9 N. 11th st L
Ferguson, Jos. C., Engineer, 522 Walnut st 1st
Ferree, Samuel P., Publisher, 10th & Chestnut sts C
Ferrel, Jos. L., Iron Manuf'y, 110 S. 6th st C
Fesquet, A. A., Chemist and Engineer, 1322 Marshall st C
Fewsmith, Crowell S., Petroleum, 302 Walnut st C
Field, Charles J., Hardware, 633 Market st C
File, John C., Merchant, 238 N. 3d st C
Firmstone, Wm., 303 Walnut st 1st
Fisher, Joseph L
Fisher, R. A., Chemist, Gray's Ferry Road and 35th st
Fisher, Thos. R., Manufacturer, Germantown L
Fisler, Jacob H., 1516 Swain st L
Fiss, G. W., Worsted Manufactory, 106 Chestnut st C
Flanagan, James M., 420 S. Delaware ave 1st
Flanagan, Stephen, 420 S. Delaware ave 1st
Flanigen, C. Douglass, Mechanical Engineer, 2120 Spruce st C
Fleischmann, A. F., Electrician, 502 Arch st C
Fleming, Wm. A., Metal Refiner L
Fodell, Wm. P., Secretary, 58 Laurel st C
Forsyth, Joseph W., Plumber, 619 Walnut st L
Foster, Chas. E., Clerk, 1233 Chestnut st L
Foster, Joshua, Teacher, N. W. Broad and Pine sts C
Fouche, Franklin H., Salesman, 239 N. 6th st L
Fouche, W. W., Dentist, 239 N. 6th st 2d
Fowler, Phillip H., Manufacturer, Gloucester City, N. J. C
Fox, Samuel L., Optician, 924 Chestnut st C
Fraiser, James, Carpenter, 331 Pine st C
Fraley, Frederick, President, 417 Walnut st 1st
Fraley, J. C., 2617 Delancey Place 1st
Frame, Gibbons, Machinist, 1318 N. 2d st C
Frazer, Persifor L
Frazer, Persifor, Jr., Geologist, 917 Clinton st C
Frederick, Montgomery L., Engraver, 153 S. 4th st L
Freedley, Dr. Samuel, Conshohocken, Pa. L
Freeman, Harold A., C.E., 12 West Penn sq 2d
Fry, Jacob W., 908 N. 5th st L
Fry, Paul Jones, Insurance Broker, 1734 Mt. Vernon st C
Fulton, Mahlon, Wagon Builder, 20th and Filbert sts C
Furbush, M. A., Machinist, 212 Market st C
Furman, S. T., Carpenter, 1713 Girard av C
Furness, Howard H., 7th & Locust sts L

Galloway, Wm., Pottery, 1725 Market st C
Gardiner, Jr., John, Brewer, 21st st and Washington av C
Gardiner, Rich'd, M.D., N. E. 17th and Arch sts L
Gardner, G. Clinton, C. E., Altoona, Pa.
Gardner, Wm. D., Carriage Builder, 214 S. 5th st 2d
Gardom, George, Druggist, 19 S. 7th st C
Garrett, S., Paper, 12 and 14 Decatur st C
Garrett, William E., 224 S. Front st C
Garrett, W. E., Jr., Merchant, 224 S. Front st C
Garrigues, S. S., Chemist, E. Saginaw, Mich. L
Gartley, Jos. C. L
Gawthrop, Henry, Coal, 311 Walnut st C
Geddes, Wm. F., Printer, 2001 Wallace st L
Geisser, I. H., Machinist, 177 Dauphin st C
Genth, F. A., Chemist, 1212 Fairmount av C
Genth, F. A., Jr., Chemist, 1212 Fairmount av 2d
Gemrig, J. H., Surgical Inst., 109 S. 8th st C
Gerker, Henry, Manufacturer L
Ghriskey, Chas. M., 508 Commerce st L
Gibbons, Chas., Lawyer, 212 S. 3d st L
Gibson, J. Howard, M. E., 1612 Walnut st C
Gilbert, John W., Machinist, 1709 S. Broad st C
Giles, Joel, Counsellor at Law, Boston, Mass. L
Gilpin, Chas., Lawyer, 336 S. 13th st L
Gilpin, George, Broker, 1825 Delancey Place L
Glass, James, Elec. Med. Apparatus, 1413 Chestnut st 2d
Gleason, Wm., Millwright, 923 Girard av C
Glessner, Oliver P., Printer, 240 Federal st L
Glocker, G., Machinist, 1019 Columbia av 2d
Gobrecht, Wm. H., M.D. L
Godbough, John W. 1st
Goehring, J. M., Mach'st, 2144 Columbia av 2d
Goforth, Edmund, Saw Maker, 133 Richmond st C
Goforth, Samuel, Jr., Carver, N. W. 10th and Arch sts, 2d floor C
Goodman, George, Printer, 1 Sergeant st L
Goodwin, W. W., Meter Mfr., 1016 Filbert st C
Gorgas, John, Miller, Roxborough, Pa. L
Gormley, Patrick, Plumber, 10th and Cherry sts C
Gowen, Franklin B., President Pottsville and Reading R. R., 204 S. 4th st C
Graff, Frederick, Civil Eng., 1337 Arch st L
Graham, Arch'd M., Superintendent, Gloucester City, N. J. C
Grahame, I. J., Pharmacist, 29 N. 12th st C
Gramlich, G. A., Stone Mason, Hutchinson st and Girard av 2d
Granger, A. O., 22 and 24 N. 4th st C
Gray, Henry W., Piano Mfr., 1103 Chestnut st C
Gray, Richard, Student, 1130 S. 9th st C
Greble, Edwin, Marble Yard, 1708 Chestnut st L
Greble, Edwin, Jr., 1708 Chestnut st 1st
Greene, Albert S., Engineer, Colonnade Hotel
Green, Samuel S., Teacher, Swarthmore Colle

Greer, Thomas, Machinist L
Grier, M. J., Physician, 1531 Spruce st C
Griffith, R. E., Attorney, 1808 Locust st C
Griswold, J. W., Manufacturer, 1500 Spruce st C
Grosz, Clement C., Book-keeper, 1233 N. 5th st C
Grubb, F., Grocer, N. W. 11th and Fairmount av C
Gumbes, Samuel W., 12th ab Arch st L
Gumpert, B. B., M.D., 840 Franklin st L
Gutekunst, F., Photographer, 712 Arch st L

Hacker, Wm., Agricultural Impl., 214 Walnut st L
Haddock, D. Jr., 426 Walnut st 1st
Haffelfinger, C. C., Publisher, 624 Market st 1st
Hagerman, J. J., Milwaukee, Wis. L
Hagert, H. S., Attorney, 2125 Sp. Garden st L
Haig, John, Coach Painter, 1236 Girard av C
Haines, A. W., Carpenter, 1513 Marshall st L
Haines, Henry, Surveyor, 512 Walnut st C
Haines, Henry C., Germantown, Pa 1st
Haines, J. S., Farmer, Germantown, Pa L
Haines, Miss Jane R., Gèrmantown, Pa L
Haines, Reuben, Germantown, Pa 1st
Haines, Robt. B., Germantown, Pa L
Haines, Robt B., Jr., Student, Cheltenham, Pa C
Halbach, E., Agent, 39 N Front st C
Hall, Augustus R , 709 Market st C
Hall, Edward S., 427 Chestnut 2d
Hall, Geo. W., 1131 Arch st L
Hall, James I., Machinist, 1037 Almond st 2d
Hall, John, Machinist, 2415 Jefferson st C
Hall, Oliver L., Bookkeeper, 1121 Girard st
Hall, Walter F., 1742 Green st C
Hallowell, C. F., Grocer, 923 Green st L
Hambilton, Job, Perfumer, 221 Spruce st C
Hand, Alfred, Clerk, S E 3d and Walnut sts C
Hand, James C., Merchant, 614 Market st L
Hand, S. Ashton, Machinist, Toughkennamon, Chester, Co., Pa. C
Hand, T. C., Jr., 1506 Arch st C
Handy, E. Smith, Merchant L
Hanold, John, Bookkeeper, 303 New st C
Hanson, H. Cooper, 3 Logan square L
Hanson, W.R., Merchant, 1812 S. Rittenhouse sq L
Harding, Geo., Attorney, 900 Chestnut st L
Harkness, Wm., Plumber, 247 S. 3d C
Harned, Frank P., Clerk, 140 S. Delaware av C
Harper, Jr., Bricklayer, 623 Federal st L
Harrington, Edwin, Machinist, 504 N. 18th st C
Harris, T. A., Dyer, 1303 Hancock st C
Harris, Geo. S., Printer, 4th and Vine sts L
Harris, Wm , Druggist, 1 Arch st L
Harrison, A. C., Sugar Refiner, 101 S Front st 1st
Harrison, G. L , Jr., Manufac, 1704 Locust st 2d.
Harrison, John, Merchant, 1520 Locust st C
Harrison, W.W., Sugar Refiner, Almond above Delaware av C
Hart, Abram, 1411 Arch st L
Hart, H. C., Physician, Walnut & Juniper sts C
Hart, S., Bricklayer, 1104 Wallace st 2d
Hart, S., Card Manufactory, 1819 Chestnut st L
Hartman, J. M., Machinist, 1237 N. Front st 1st
Hartshorne, Chas., V. Président, 238 S. 3d st L
Hartshorne, H., M. D., Haverford College, Del. Co. Pa. L
Harvey, Alexander E. L
Haslam, John G., M. E., 1912 Mascher st C
Hatfield, Walter, Manufac., 501 Franklin st C
Haug, J., Draughtsman, 417 Walnut st C
Haupt, L. M., C. F , 3910 Baltimore av C
Heald, E. W., 1321 Green st C
Heberton, George, 52 S. 3d st C
Hefti, Matthias, Designer, 305 New st C
Heller, C. F., 853 N 20th st 2d.
Heller, C. S., Inst. Maker, 33 N. 7th st C
Helme, Wm , Gas Meters, 1117 Cherry st 1st
Helme, Wm. E. 1719 Vine st 1st
Henderson, Edward, Hatter, 19 N. 3d st L
Henderson, Henry F., Clerk, 825 Arch st C
Hendry, J. A., Leather Merchant, 67 Chestnut st L
Henis, Chas. F., Tinsmith, 1202 N. 19th st C
Henry, Geo. H., Salesman, 113 Arch st C
Henszey, S. A., 316 Chestnut st C
Henszey, S. C., Salesman, 954 N. 6th st L
Henszey, Jos. G , Mining. 216 S 4th st C
Hering, Rudolph, C. E., 2226 Brandywine st C
Herwig, Emilius, Apothecary, 3d and Brown sts C
Hess, Eli, 1434 Fairmount av L
Hewett J., Merchant, 409 Market st L
Hewston, G., Physician, 766 Vine st L
Heyl, H. R., Manufacturer, 3917 Aspen st C
Hibbs, J. M., Manuf., 1330 Buttonwood st C
Hill, Rufus, Master Mechanic, C. & A. R. R., Camden, N. J. C
Hipple, W. Hall, 940 Race st L
Hirst, Philip, Hatter, rear of 218 Arch st C
Hockley, Thomas, 225 S. 21st st 1st
Hoehle, C., Draughtsman, 1365 Beach st C
Hoffman, Geo. E. Engineer, 259 S. 17th st C
Hoffman, J. W., C. and M. E., 259 S. 17th st C
Hofstetter, Geo., Manuf , 111 S. 8th st C
Hohenadel, John, Jr., 215 Race st 2d
Hohenadel, Theo., Bookkeeper, 2418 Brown st 2d
Holman, D. S., Actuary, 15 S. 7th st C
Holmes, Seth C. L
Hollis, P. C., Accountant, 407 Library st C
Hollinshead, B. M., 537 N. 7th st L
Hollingsworth, Sam'l S., Lawyer, 411 Walnut st C
Holzer, E. R., Painter, 1507 Stiles st C
Hoover, H. N., Constructor 323 Wharton st L
Hopper, Thos. C., Gas Maker, N.W. 22d and Arch sts C
Horne. C. H., Merchant L
Horstmann, F. O., Manuf'r, 5th and Cherry sts L
Hoskins, John, 720 Wood st 2d
Hoskins, Raper, Fancy Store, 913 Arch st C
Houseman, Thos. R., Machinist, Gloucester City, N. J. C
Houston, Prof, Edwin J., Cent. High School 1st
Houston, J. F., Civil Eng'r, Columbia, Pa. L
Howard, C. W., Inventor, 1505 Ridge av C
Howard, G. C., Machinist, 13 S. 18th st L
Howard, John L., Sup't, 718 E. Cumberland st C

Howard, W. H., Media, Delaware Co., Pa. L
Howe, H. M., Physician, 1606 Locust st 1st
Howell, G., Paper Hangings, 1216 Chestnut st C
Howell, W., Paper Manuf'r, 12 S. 6th st L
Howell, Z. C., Paper Hangings, 12 S. 6th st C
Howson, H., Patent Attorney, 119 S. 4th st 1st
Howson, Hubert, Att'y at Law, 119 S. 4th st 1st
Huff, J. W., Printer, 705 Jayne st C
Hullinger, J. W., Teacher, Beverly, N. J. C
Humiston, R. F., Chemist, 41 S. 4th st C
Hunt, J. G., Physician, 1802 Wallace st C
Hunter, J., Calico Printer, 55th and Paschall sts L
Hunter, J. C., Plumber, 1150 S. Broad st L
Hunter, H., Gas Fitter, 55th and Paschall sts L
Hutchinson, J., California L
Hutchinson, Israel P. 1st
Hutchinson, Robt,, Notary, 1416 Fairmount av L
Hutton, Finley, Builder, 120 N. 13th st C

Iddings, Frank H., Clerk, 114 S, 2d st C
Iddings, Frederick T., Clerk at Clementon Station, Narrow Gauge R. R , N. J C
Ide, Chas. K., Master of Transportation, Broad st and Washington av C
Imadate, Tosui, Student, 107 S. 34th st C
Ingersoll, Harry, U. S. Navy L
Ingham, W. A., President, 320 Walnut st C
Irwin, J. H., Morton, Delaware co., Pa C
Ivens, A. B., Teacher Friends' Central school L

Jack, Louis, Dentist, 1533 Locust st C
Jackson, S., Pyrotechnist, 1414 Ellsworth st C
James Bushrod W., Physician, 18th & Green sts C
James, Sam'l, Machinist, 519 N. 43d st C
Janney, B. S., Jr., Grocer, 123 Market st C
Jarrett, Wm., Clergyman, 1814 N. 12th st C
Jayne, E. C., Druggist, 42 Chestnut st L
Jeanes, J. T., Merchant, 1023 Arch st L
Jeffreys, Wm., Blacksmith L
Jeffry, Struthers, Machinist, 2477 Frankford rd C
Jenks, B. H., Machine Maker, 402 Locust st L
Jessup, Alfred D., Aldine Hotel 1st and L
Jewell, Leonard, Merchant, 1425 Chestnut st L
Johnson, Chas. Eneu, Ink Manuf., 500 S. 10th st L
Johnson, A. B., Carpenter, 178 N. 10th st C
Johnson, E. H., Machinist, 23d and Washington av C
Johnson, Geo. L., 5th and Library sts L
Johnson, Geo. R., Tinsmith, 7th and Sansom sts L
Jones, Alfred, Ross st., Germantown L
Jones, F. P., Mech. Engineer C
Jones, Geo , Teacher, 186 N. Front st L
Jones, Geo. W., Clerk, 1328 Spruce st L
Jones, J. P., Merchant, 1608 Market st 1st and L
Jones, Nathan F., C E , Norristown, Pa L
Jones, Owen, I'n Founder, 16th and Market sts L
Jones, Owen, Merchant, 200 Market st L
Jones, Warner C., Hardware, 2809 Girard av L
Jones, Washington, Steam Engineer, Richmond and Ball sts L

Jordan, John, Jr., Merchant, Historical Society, Spruce above 8th st L
Justi, Henry D., Dentist, 516 Arch st C
Justice, Wm. W., 122 S. Front st C

Kaighn, Robert, Bricklayer and Builder, Camden. N. J C
Kaighn, Mary M., Teacher, 1419 Walnut st C
Kain, Wm., Shoe Manuf'r, Beverly, N. J C
Keefer, Wm. W., 1416 Chestnut st. In trust for Wm. B. Keefer 1st
Keeley, Jerome, Tin Plate, 206 Walnut Place 2d
Keerl, James S., C.E., 3313 Spring Garden st C
Kehfuss, Geo., Superintendent, 20th st and Washington av C
Kelley, Henry H., Druggist, 1706 Green st L
Kelly, Wm. D., Attorney at Law, Myrtle and N. 41st L
Kendall, E. O., Teacher, University Penna C
Kennedy, R. G., Architect, 735 Walnut st C
Kennedy, Elias D., Broker, 308 Walnut st 2d
Kennedy, John M., 1423 Arch st 1st
Kern, John, Draughtsman, 1015 Rate st L
Ketterlinus, E., Printer, N. W. 4th and Arch sts L
Keyser, Andrew D., Brick Maker, 236 S. 20th st C
Kichner, J. T., Merchant, 812 E York st C
Kile, John, Pattern Maker, 808 N. 17th st L
Kilgore, John, House Carpenter, Wood and Juliana sts L
Killie, John T., 1822 Green st 1st
King, Thomas, Carpenter st L
King, Wm. T., Clerk, Camden, N. J L
Kinsey, Wm., Jr., Morocco Man., 3d and Vine sts C
Kirk, J. J., Clerk, 303 Walnut st 1st
Kirk, Geo. H., 1528 Brown st 1st
Kirkbride, Thos. S., Physician, 44th and Haverford sts C
Kirkpatrick, Alex. E., Hide Dealer, 3d & Vine sts C
Kirkpatrick, Jas A., Asst. Sup't Girard Estate, 2014 Vine st L
Klapp, Jos., Physician, 622 Spruce st L
Klauder, Jonn H. A , Manufacturer, 333 Arch st C
Kneass, Napoleon B., Saddle Manf., 2121 Columbia av L
Kneass, Strickland, Civil Eng., 233 S. 4th st C
Knight, Daniel R L
Knight, E. C., Merchant, 1605 Chestnut st L
Knight, Hartley, Merchant, 1222 Chestnut st 2d
Knorr, J. Francis L
Koenig, Geo. A., Prof. Chemistry, 3603 Atlanta st C
Kramer, Henry, 1345 Palmer st 2d
Krider, Peter L., Silversmith, 618 Chestnut st C
Krumbhaar, Alex.. File Manufactory, 1601 Spring Garden st C
Kuhn, Chas., Broker, 1712 Spruce st L
Kuhn, C. Hartman, Broker, 1712 Spruce st L
Kuhn, Hartman, Jr., 240 Walnut st L

Lagomarsino, A., Mfr., 8th and Christian sts C
Laing, Henry M., Shoe Findings, 335 N. 11th st L
Lamb, Ridgway H., Dentist, 512 N. 3d st C

Lambdin, Jas. R., Artist, 1224 Chestnut st L
Lambert, John, Attorney, 420 Walnut st L
Large, Daniel, Engineer, Poplar ab 2d L
Larkins, Frank J., Rigger, New P. O., 915 Chestnut st C
Latimer, Thos., 432 Library st C
Lawrie, C. W., 229 S. 10th st 2d
Lea, Henry C., Pub., 706 Sansom st L
Lea, Isaac, Bookseller, 1622 Locust st L
Lea, M. Carey, Attorney, 426 Walnut st L
Lea, Francis H. 1st
Leavitt, E. D., M.E. 2d
Le Boutillier, Roberts, Germantown L
Le Conte, John, Physician, 1625 Spruce st L
Lee, Geo. Burtis, 533 N. 6th st C
Lee, Geo. F., Builder, 533 N. 6th st L
Lee, Thos. D., Grate Maker, 329 S. Broad st L
Leeds, Josiah W., Real Estate, 528 Walnut st 2d
Lefrance, Emile, Prof., 112 S. 17th st C
Lejee, Wm. R., Broker, 1801 Walnut st L
Lennig, Chas., Wools, 112 S. Front st L
Lennig, Eugene, Chemist, 1300 Walnut st C
Lenthall, John, C.E., Washington, D. C. L
Lesley, Jos., Secretary, 233 S. 4th st C
Leuffer, A. B., C.E., 2036 Mt. Vernon st C.
Le Van, W. B., Engineer, 3607 Baring st L
Lever, Jas. S., Bookbinder, 46 N. 7th st C
Levering, W. M., Draughtsman, 410 Walnut st 2d
Lewis, A. Nelson, 1314 Spruce st C
Lewis, Ed. M., President, 427 Chestnut st C
Lewis, Enoch, Purchasing Agt., 233 S. 4th st C
Lewis, Geo. F., Plate Printer, 33 S. 3d st L
Lewis, Henry Carville, East Washington Lane, Germantown L
Lewis, John L., Merchant, 231 S. Front st 1st
Lewis, Wilfred, Mechanic, 33d and Powel'n av 2d
Lewis, W. J., C.E., San Francisco, Cal. L
Lex, J. H., Secretary, 34 N. 5th st L
Lightfoot, Jesse, Lawyer, 61 Harvey st, Germantown C
Lindsay, R., Publisher, 528 Franklin st L
Linville, J. Hays, Engineer and Architect, 218 S. 4th st C
Lipman, H. L., Stationer, 411 Walnut st C
Lippincott, J. Dundas, 509 S. Broad st C
Lippincott, Howard W., Broker, 202 Walnut Place C
Lippincott, C., Manufacturer, 916 Filbert st C
Lippincott, Hilles, Book-keeper, 920 Franklin st C
Lippincott, J. B., Publisher, 717 Market st 1st and L
Lippincott, Josh., Jr., Clothier, 538 N. 6th st C
Littleton, Wm. E., 514 Walnut st 1st
Livesey, John, 1123 Arch st 1st & L
Lloyd, Mrs. F., Teacher, 1615 Chestnut st C
Longacre, Matthias R., Engraver and Lithographer, 706 Chestnut st C
Longstreth, Ed., Machinist, 500 N. Broad st C
Longstreth, J. Cooke, Lawyer, 125 S. 7th st C
Loper, Capt. R. F. L
Lovering, Jos. S. L
Luder, Thos. L. L
Lukens, Amos, Blacksmith, Plymouth Meeting P. O., Montgomery co., Pa. L
Lukens, David L., Clerk, 1600 Hamilton st 2d
Lukens, Jas. T., Dry Goods, 531 Marshall st L
Lukens, Jawood, Iron Manufacturer, Conshohocken, Pa. C
Luthy, Otto, Chemist, 451 N. 4th st C
Lynn, John W., 426 S. Delaware av 1st
Lyon, C. Wesley, Chemist, 215 S. Front st C

Maas, Chas. E., Engraver, 1619 Norris st L
Maas, Wm. A., Printer, 1337 Mt. Vernon st L
MacCallum, Hugh, Machinist, Germantown C
MacHarg, E., Teacher, S. W. 16th & Spruce C
Magargee, Charles, Paper Dealer, 6th and Jayne sts L
Magee, Frank H., 1219 Arch st 1st
Magee, James R., 1219 Arch st 1st
Magee, Michael, Saddler L
Maloy, Henry W., 1515 S. 5th st 2d
Marcy, L. J., Optician, 1340 Chestnut st C
Maris, John M., Chemist, 711 Market st C
Marks, Wm. D., Prof., University, 36th and Locust sts C
Marriner, S. R., Carpenter and Builder, 716 Cherry st C
Marshall, Samuel R., Machinist, 923 N. Broad st C
Martin, Jas., Jr., Machinist, 1 Coombs Alley L
Martindale, J. C., Cashier, 322 Penn st, Camden N. J. C
Mason, Jas. S., Mfr., 140 N. Front st 1st
Mason, Samuel, 220 S. 4th st L
Massey, W., Brewer, 10th and Filbert sts 1st
Matlack, J. R., Phyiscian, Race & Chester sts L
Matlack, J. David, 1057 Richmond st 2d
Matthieu, J. A., Chemist, 815 Broadway, Camden, N. J. 2d
Matthews, W. G., 2022 Mt. Vernon st 1st
Matthews, Wm., 2022 Mt. Vernon st 1st
Maule, E., Lumber Dealer, 2500 South st C
Megargee, S. J., Merchant, 20 S. 6th st C
Megargee, Theo., Paper Mfr., 20 S. 6th st C
Melchor, Martin V. B. 1st
Mellor, Alfred, Chemist, 218 N. 22d st C
Mellor, Thos., Merchant, Chelton Hills, Pa. L
Menamin, S. R., Publisher, 515 Minor st C
Merrick, J. Vaughan, Roxborough, Phila. 1st & L
Merrick, Wm. H., Machinist, 230 S. 3d st 1st & L
Merrihew, James, Telegrapher, 1001 Chestnut st C
Mershon, George B., Heaters, 40 N. 12th st C
Messchert, M. H., Lawyer, 1528 Arch st L
Middleton, C., Iron, 2d and Willow sts L
Middleton, C. W., Iron, 945 Ridge av 2d
Middleton, H. W., Iron, 945 Ridge av 2d
Middleton, Nathan L
Miller, Adolph W., Physician, 860 N. 5th st 1st
Miller, D. K., Lock Mfr., 720 Cherry st 2d
Miller, Edward, C. E., 246 Spruce st L
Miller, E. W., Bookbinder, 1792 Vine st L
Miller, Frank L., Engineer, 717 E. Dauphin st C

Miller, Jas. H., Brass Founder, 1028 Spring Garden st C
Mills, Chas. K., Physician, 1502 Columbia av C
Milne, Caleb J., Mfr., 2030 Walnut st L
Milne, F. F., 1520 Arch st 1st
Mingus, P. P., Blacksmith, Cherry & Juniper sts L
Minister, Jos. B., Color Mixing, 18th & Washington av C
Missemer, J. H., Salesman, 808 Market st 2d
Mitchell, J. B., 715 Market st 1st
Mitchell, Jos. E., Merchant, 310 York av C
Mitchell, Wm. A., Merchant, 224 Federal st Camden, N. J. L
Moody, Edward F., Camden, N. J. L
Moore, Geo. R., Minister, 1820 Cayuga st C
Moore, Henry D. 1st & L
Moore, Jas., Machinist, 16th & Buttonwood sts 1st
Moore, Wm. H., Undertaker, 1610 Arch st L
Moore, Wm. J., Carpenter, 1719 S. Rittenhouse st L
Morgan, Thos. A. L
Morgan, Wm., Gentleman, 410 N. 11th st C
Morrell, D. J., 218 S. 4th st 1st
Morris, Daniel J. 1st and L
Morris, Henry, 207 Spruce st L
Morris, Henry G., Iron Manuf'r, 5th and Washington av L
Morris, Israel, 1608 Market st 1st
Morris, Israel W., 238 S. 3d st C
Morris, J. Cheston, Physician, 1514 Spruce st C
Morris, Wistar, 3d and Walnut sts L
Mortimer, Chas.. Copper Plate Pr't'r, 297 Vine st L
Morton, Prof. Henry, President. Hoboken, N. J. L
Morton, Rev. Henry J., 909 Clinton st 1st
Moss, Theodore F., Mining Eng. L
Muckle, Alex., Chemist, 1321 N. 19th st C
Muckle, M. R., General Manager, 600 Chestnut st C
Murphy, Wm. C., Painter, 181 S 2d st L
Murphy, Wm. R., Attorney at Law, 130 S 6th st C
Murray, Chas. W., Stereotyper L
Murray, Matthew, Machinist L
Murray, Peter, Founder, 2214 Brandywine st C
Murray, Samuel A., Jr., 1711 Fairmount av C
Murta, John P., Accountant, 249 S. 8th st L
McAllister, F. W., 56 Lexington st., Baltimore, Md. C.
McAllister, W. Mitchell, Optician, 728 Chestnut st L
McAlpine, Daniel, Machinist, 1422 N. 18th st C
McArthur, John, 408 S. Broad st L
McArthur, John, Jr., Architect Public Buildings, Broad and Market sts C
McCall, Peter, Attorney at Law, 224 S. 4th st C
McCambridge, Richard, Brass Founder, 527 Cherry st C
McCambridge, S., Saddler, 523 Cherry st C
McCaffrey, Hugh, File Manuf'r, 1736 N. 4th st C
McCaffrey, John, File Manuf'r, 1615 N. 4th st C
McCahan, Jas. M., 1813 S. 2d st C
McCarter, Wm., Painter, 1515 S. 6th st C
McCausland, Wm. J., Manuf'r, 132 Market st C
McClure, John, Builder, 21 S. 16th st L
McCollin, Jas. G., 1600 Hamilton st 2d
McCollin, Thos. H., Photographic Supplies, 624 Arch st C
McCollom, T. C., C. E., 1811 Lee st C
McComb, Arthur M., Superintendent, 4406 Frankford av C
McConn, John, Inventor, 920 Walnut st C
McConn, Wm. S., Steam Heaters, 920 Walnut st C
McCowan, John L
McCurdy, John R., Manuf'r, 116 Arch st L
McCutcheon, W. H., Oil Cloth, 418 Arch st C
McDowell, John, Carpenter, 626 Filbert st C
McElroy, A. C., 1413 S. 4th st 2d
McFadden, Wm. H., C. E., 13th and Spring Garden sts 2d
McIlhenny, John. 1st
McIlvaine, A. Robinson, Drug and Spice Mill, 15th and Hamilton sts L
McInnes, J. T., Lime Merchant, 9th below Master st C
McIlvaine, Wm. L
McIntyre, C., House Carpenter L
McKay, Angus, Planter, Queensland, Australia C
McKean, W. V., Manager *Public Ledger*, 6th and Chestnut sts C
McKinley, Benj. B., Teacher, 425 S. 16th st L
McMurray, Andrew S., Physician, 325 Pine st L

Naylor, Jacob, Iron Founder, Front & Girard av L
Neal, Wm., 536 N. 7th st L
Needles, Samuel H., Manuf'r, 337 S. 5th st C
Negus, J. Engle, Merchant L
Nelms, Henry, Gold Beater, 46 N. 7th st L
Neumann, Joseph, Manuf'r, 919 Race st 2d
Nevil, Wm., H., Morocco Manuf'r, 144 Margaretta st C
Newbold, J. S., Merchant, 719 Pine st L
Newbold, T. M., Druggist, 105 S. 41st st 2d
Newhall, George, 528 Spruce st C
Newhall, G. M., Sugar Refiner, 225 Church st C
Newlin, John S L
Newman, John S., Jeweller, 433 Green st C
Nicholson, C. L., Lumber, N. W. 7th and Carpenter sts L
Nicholson, Jos., 808 N. 16th st C
Nicholson, Richard L L
Norris, Charles, 1925 Spruce st L
Norris, George L., 1829 Memphis st C
Norris, Isaac, Lawyer, 617 Walnut st C
Norris, I., Jr., Physician, 1424 Walnut st 1st
Norris, Richard 1st
Norris, Thaddeus, Engineer, 229 S. 18th st 1st
Nugent, E., Druggist, 18 N. Front st C
Nystrom, J. W., C. E., 1010 Spruce st L

Oat, G. R., Coppersmith, 1307 Arch st C
Oat, Jos., Coppersmith, 232 Quarry st C
O'Bryan, J. Duross, Atty at Law, 213 S. 6th st C
Odenatt, W. H., Millwright, 1527 Savery st C
O'Driscoll, C. F., Stereotype Founder L
Oesterle, H. G., 848 N. 6th st L

Oesterle, P., Draughtsman, 232 Quarry st C
Ogden, Rich'd I., Manuf'r, Paschall st, 27th Ward C
Oldach, Frederick, Bookbinder, 16 S. 7th st C
Oliver, G. L., 1412 Arch st 1st
Olsen, T., M. E., 1958 N. 11th st C
Orr, H., Printer, 202 Chestnut st L
Orum, M. L., Machinist, 448 N. 12th st C
Ott, G. F., Coppersmith, 213 Buttonwood st C
Ourt, L., Black and White Smith, Riverton, N.J. C
Outerbridge, Alex. E., Jr., Assay Laboratory, U.S.M. C

Paige, F. E., Stationer, 1812 Filbert st C
Palmer, B. F. Surgeon Artist, 1609 Chestnut st L
Palser, J. B., Manuf'r, Belleville, N. J. C
Pancoast, C. S., Attorney, 416 Walnut st C
Pardee, A., Coal, Hazleton, Pa 1st
Pardee, A., Jr., Iron, 303 Walnut st 1st
Pardee, Calvin, Coal, Hazleton, Pa 1st
Parke, J. P., Trenton, N. J. C
Parker, G., House Carpenter, Berkley, Gloucester Co., N. J. L
Parker, J. L
Parker, W. H., Teacher, School 8th and Fitzwater sts C
Parkinson, R. B. L
Parrish, D., Druggist, 1017 Cherry st L
Parrish, Edward, C. E., 532 Walnut st
Parry, C. T., Machinist, 500 N. Broad st L
Partrick, J., Telegrapher, 114 S. 2d st C
Patterson, A. H., Clerk, 419 N. 6th st 2d
Patterson, Robert, Treasurer, 329 Chestnut st C
Patterson, Wm. H., Lawyer, 49 S. 3d st C
Patton, T. R., Merchant, S. E. 13th & Locust st 1st
Peirce, Parker D., Druggist, 4th & Lombard sts C
Peltz, P. G., Eng. U. S. N., Schuylkill Falls L
Pemberton, Henry, Gentleman, 1947 Locust st C
Pemberton, Harry, Jr., Chemist, 1947 Locust st C
Pepper, Geo. S., Attorney at Law, 704 Walnut st C
Pepper, Lawrence S., M. D., 1219 Walnut st C
Perkins, A. R., Merchant, 102 S. 9th st L
Perkins, Geo. H., Tinsmith, 413 S. Broad st C
Perot, Effingham, Cashier, 400 Walnut st C
Perot, T. M., Druggist, 1810 Pine st L
Perry, W. G., Bookseller, 728 Arch st L
Peterson, W., Chemical Works, 1014 Dickinson st C
Petraeus, V., Chemist, 231 S. Front st C
Pettit, H., C. E., 1509 Walnut st C
Pettitt, W., 2131 Mt Vernon st L
Philbin, S. R., Plumber, 204 N. 19th st C
Phillips, Chas. C., 934 N. 5th st 1st
Phillips, Cyrus, 617 Arch st C
Phillips, W. J., S. W. 5th and Chestnut sts. C
Phillips, G. Brinton, Chemist, 8 N. 7th st C
Pierce, Chas. D., Manager, 4204 Elm av C
Piers, Louis J., Accountant, 1201 Green st L
Pike, Chas. F., Machinist, 1625 Francis st C
Pistor, Philip, Draughtsman, 2318 St. Alban's Pl. C
Pleasanton, Gen. A. J., 918 Spruce st 2d
Plush, Samuel M., M.D., Electrician, 3d & Chestnut sts C
Potter, Thos., Oil Cloth Manuf'r, 418 Arch st L
Potts, Albert, Iron Merchant, 238 N. Front st L
Powell, John M., 3613 Powelton av 1st
Power, L., Machinist, 3003 Chestnut st C
Pratt, Daniel R., Machinist, Worcester, Mass. L
Price, Chas. H., Cashier, Burlington, N. J. 2d
Price, Jacob S., Carpenter, N. W. 11th and Shippen sts L
Price, Joseph L
Price, Samuel, Bricklayer, Darby, Pa. L
Price, Wm. S., Attorney at Law, 633 Walnut st C
Prince, Samuel F., 2214 Chestnut st C
Procter, Wallace, Apothecary, 900 Lombard st C
Pugh, Chas. E., 3003 Market st C
Purves, A., Merchant, 17 South st L
Purves, Chas., 17 South st C

Quig, Henry, Copper Plate Printer, 3762 Fkd rd L
Quigley, John F. Contractor, Wilmington, Del. C
Quintil, Chas. J., C. & M. E., 2121 Brandywine st C

Rand, B. H., M. D., 1615 Summer st L
Rand, Theo. D., Attorney, 17 S. 3d st L
Randall, J. Colvin, 1905 Chestnut st 2d
Randolph, Evan, Merchant, 2002 Arch st L
Randolph, Wm., Clerk, Arch and 20th sts L
Rappley, H. W., Manuf'r, 1430 S. Penn Square C
Rawle, Francis, Attorney at Law, 402 Walnut st C
Rea, W. Howell, Carpenter, 1803 Poplar st C
Reaney, Robt., L., Machinist, Frankford L
Redfield, John H., 216 W. Logan Spuare 1st
Redfield, Robt. S., 1600 Callowhill st 1st
Reed, Henry H., Merchant, 1425 Chestnut st L
Reed, Mary, Miss, Teacher, 1320 Arch st C
Reeves, Ellwood L
Reeves, Samuel J., 414 Walnut st L
Reid, A. H., Manuf'r, 6 N. 18th st C
Remsen, Geo. C., Publisher, 624 Market st 1st
Reynolds, Jesse, Heaters and Ranges, 13th and Filbert sts C
Rhoads, Joshua, Physician, Jacksonville, Ill L
Rhoads, Wm. G., Plumber, 1221 Market st C
Rice, Jas. D., 11 S. 7th st 2d
Richards, John, Atlantic Works, 22d ab. Arch st 1st
Richards, G. W., Manuf'r, Broad and Spruce sts L
Richards, Geo., M. E., Wilmington, Del. C
Richards, Samuel, President, 402 Locust st C
Richardson, David D., Physician, Almshouse C
Richardson, Geo. J., Fire-arms L
Ridgeway, Thos., 1705 Walnut st 1st
Ridgway, John J., Jr., Attorney, 204 S. 7th st C
Riehle, Henry B., Scales, 9th ab. Master st C
Ritchie, C. D., Conveyancer, 508 Walnut st C
Riter, John A., Builder, 610 N. 10th st L
Rittenhouse, Henry N., Manuf'g Chemist, 218 N 22d st C
Robbins, John, Steel Mf'r., 917 Shackamaxon st L
Roberts, Alfred R., C. E., Berks & American sts C
Roberts, Caleb C., Adams Expr. Co., 1118 Arch st L
Roberts, Chas., Manuf'r, 410 Race st C
Roberts, C. J., Dry Goods, 912 Chestnut st 2d

Roberts, Edward F., Miner, N. Brunswick, N.J. C
Roberts, Elihu, Secretary, 307 Walnut st L
Roberts, Geo. B., 1901 Spruce st 1st
Roberts, Geo. Theo., 314½ Walnut st 1st
Roberts, Mary F., Teacher, 1522 Arch st C
Roberts, Percival, 265 S. 4th st 1st
Roberts, Sol. W., C. E., 407 Walnut st 1st & L
Roberts, W. Milnor, C. E., Iselin, N. J. L
Robinson, E. W. L
Robinson, Thos. A., Merchant, 1926 Race st C
Rockafeller, John, Merchant, 733 South st C
Rogers, C. B., Merchant, 133 Market st C
Rogers, Fairman, 202 W. Rittenhouse sq. 1st & L
Rogers, Fairman, in trust for Franklin A. Dick, 1709 Locust st 1st
Rogers, Prof. Robt. E., 1004 Walnut st L
Rogers, W. D., Coach-maker, 1009 Chestnut st C
Rogers, Wm. B., Jr., Vice-President and Treasurer, 1000 Walnut st C
Rohrman, Jos. B., Clerk, 610 Cherry st C
Rolin, W. A., Carpet Dealer, 739 Market st L
Roney, Chas. H., 715 Sansom st C
Root, H. C., 1111 Chestnut st C
Rosengarten, G. D., Chemist, 1532 Chestnut st L
Rosengarten, H. B., Manuf'r, 325 S. 17th st C
Rosengarten, M. G., 1815 Spruce st 1st
Rosengarten, Samuel G., 1532 Chestnut st L
Rothermel, J. G., Coal, 9th and Master sts 2d
Rowand, J. R., Physician, 1714 S. 6th st L
Rowland, Edward 1st
Rudder, Wm., D. D., 1539 Pine st C
Rumpf, C. F., Manuf'r, 118 N. 4th st
Ruschenberger, W. S. W., Medical Director, U.S.N., 1932 Chestnut st L
Rutherford, Wm. H., Chief Eng. U.S.N., 1503 Spruce st L
Ryan, Thos., Merchant, 40 S. Wharves L

Safford, Henry W., 125 N. 21st st L
Sailor, Henry, Marble Cutter, 10th & Vine sts L
Salmon, C. H., Manufacturer, Oxford and Hancock sts L
Salom, Pedro G., Chemist, 1126 Walnut st C
Sandgran, C. C., Plumber, 347 Wharton st 2d
Sandgran, G. M., Plumber, 347 Wharton st 2d
Sartain, Harriet Judd, Physician, 210 Franklin st 2d
Sartain, Henry, Plate Printer, 728 Sansom st L
Sartain, John, Engraver, 728 Sansom st L
Sartain, Sam'l, Engraver, 210 Franklin st L
Sartain, William, Artist, 728 Sansom st L
Saul, Rev. James, D.D., 1630 Pine st L
Scattergood, Thos., Tanner and Currier, 278 N. Front st L
Schenck, Arch'd A., C.E., 4006 Balt av 2d
Schimmel, J. O., Fruit Preserver, 431 Master st C
Schleicher, A., Engineer, 3045 Chestnut st C
Schleicher, James, Merchant, 3045 Chestnut st C
Schmidt, Charles, Machinist, 1743 N. 6th st C
Schneider, H. J., Electrical Instrument Maker, 114 S. 2d st C
Schnell, P. F. L., Chemist, Tacony Chemical Works, Pa. C
Schober, F., Mech. Eng., 478 N. 5th st C
Schumm, H., Engineer, 119 S. 4th st C
Schutte, L., Engineer, 12th & Thompson sts C
Scott, Charles, 1128 Arch st 1st
Scott, E. Alexander, Stenographer, Room 16, Ledger Building C
Scott, Thos. A., President, 233 S. 4th st 1st
Seal, Lewis, Merchant, 136 S. 3d st L
See, Richard C., Merchant, 1501 Spring Garden st L
Seefeldt, W. F., Musical Inst. Mfr., 731 Race st C
Seiler, C., Dr., 1608 Pine st C
Selman, William, Carver, 1750 Marshall st C
Sellers, Coleman, Engineer, 1600 Hamilton st 2d
Sellers, Coleman, Jr., Machinist, 1600 Hamilton st 2d
Sellers, Jno., Upper Darby, Delaware co, Pa. L
Sellers, Jno., Jr., Machinist, 1600 Hamilton st L
Sellers, Wm., Engineer, 1600 Hamilton st L
Sewall, Basil, Agent, S. E. 11th & Carpenter sts 2d
Sexton, John W., Dry Goods Merchant, 112 S. 3d st L
Seybert, Henry, 926 Walnut st L
Shain, Chas. J., Math. Inst. Maker, 716 Chestnut st C
Sharpless, Edward, Merchant, 447 Marshall st C
Sharpless, Henry G., Merchant, 187 Arch st L
Sharpless, Isaac W., Teacher, Haverford College C
Sharpless, J. T., Physician, 1227 Arch st L
Sharpless, N. H., Lawyer, 27 N. 7th st C
Sharpless, Philip M. 2d
Sharpless, S. J., 705 Walnut st 1st & L
Sharpless, Wm. P., Merchant, 2513 Arch st L
Shaw, John Eyre, Attorney, 110 S. 4th st C
Shaw, Louis, Druggist, 838 N. 9th st C
Shaw, Thomas, Machinist, 913 Ridge av C
Sheaff, John F., Coal Dealer, 220 S. 4th st C
Sheble, R., Cabinet Maker, Bensalem P. O., Bucks co, Pa. L
Sherman, F. D., 1723 Mt. Vernon st C
Shetzline, C. W., Carpenter, 314 Dickinson st 2d
Shick, Wm. H. 1st
Shinn, Jas. T., Druggist, Broad & Spruce sts L
Shinn, John, Machinist, 32 Merchants' Ex. 2d
Shoemaker, B. H., Glass Warehouse, 205 N. 4th st C
Shoemaker, J., Publisher, 717 Market st 2d
Shoemaker, J. L., M.D., 815 Columbia av C
Shoemaker, Thos. H., 45 Tulpehocken st, Germantown C
Shoffner, W. N., 1909 Market st C
Shrigley, John M., Machinist, 2029 Callowhill st 1st
Shute, Charles F., Printer, 241 N. 5th st C
Silver, J. S., Coal Merchant L
Simons, G. W., Jeweler, 611 Sansom st 2d
Simons, H., Jr., Wheelwright L
Simons, M. P., Photographer, 1320 Chestnut st L
Simpson, Thos., Calico Printer, 1808 Spruce st C
Sinclair, Thos., Lithographer, 508 North st C
Sinex, Thos., Merchantville, N. J. L

Singer, E. A., Teacher, 4764 Penn st, Frankford 2d
Skidmore, S. T., Teacher, 17th and Spring Garden sts C
Sloan, J., Farmer, Montgomery co, Pa L
Sloat, G. B., Manufacturer, Kensington L
Smedley, A. M., Carpenter, 915 Chestnut st C
Smedley, Sam'l L., Chief Engineer and Surveyor, 224 S. 5th st L
Smethurst, John, Fresco Painter, 1241 Ridge av C
Smith, Albert H., Physician, 1419 Walnut st C
Smith, Benj., Accountant L
Smith, B. R., Broker, 4717 Main st, Germantown C
Smith, Charles B. 1st
Smith, Chas. E., Engineer, 216 S. 15th st L
Smith, Chas. W. L
Smith, DeWitt W., 135 N. 3d st C
Smith, Edwin, Machinist, 1600 Hamilton st 2d
Smith, E. M., Physician, 842 N. 8th st L
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Smith, Geo. F., Dry Goods, 133 S 11th st L
Smith, Isaac R., Merchant, 1016 Walnut st L
Smith, James Brown, 433 Arch st L
Smith, J. F., Civil Engineer, Reading, Pa. C
Smith, J. Pancoast, 1923 Spruce st L
Smith, R. R., Lawyer, 224 S. 4th st C
Smith, Samuel, Druggist L
Smith, Wm., Mech. Draughtsman, Front and Girard av C
Smith, Wm. H., Sugar Refiner, 427 Vine st, C
Smith, Wm. H., Jr., Stationer, 620 N. 7th st C
Smith, Wm. M., Machinist, 509 Locust st C
Smyth, L., Sugar Refiner, 1420 Arch st L
Snider, Geo., Bookbinder, 2311 Sp. Garden st L
Snyder, Henry 1st
Snyder, H. M., Engraver, 701 Chestnut st C
Somerville, Jas. McA., M. D., 1714 Race st L
Sparks, Thos. W., Clerk, 121 Walnut st L
Speel, Jos., Bookbinder, 25 N. 7th st L
Speidel, Geo., M. E., 1828 Wood st C
Spencer, J. A., Attorney at Law, 129 S. 5th st C
Spittal, John, Wood Engraver, 409 Chestnut st L
Spon, E., Technologist, 442 Broome st, N. Y. C
Stanton, C. W., Sheet Iron Wkr., 1506 N. 20th st C
Stanton, E. W., Merchant, 1506 N. 20th st C
Starr, Edwin P., Stereotype Fdr., 324 Chestnut st C
Starr, Thos. W., Type Founder, 324 Chestnut st C
Steele, Jas. W., Engraver, 320 Walnut st C
Steinmetz, Chas., Bookkeeper, 1029 Ridge av C
Steinmetz, Howard, Marble, 1029 Ridge av C
Stelwagen, Jos., Paper Mf'r., 525 Commerce st L
Stellwagen, Thos. C., D. D. S., A. M., 1627 Chestnut st C
Sterling, Andrew, 1600 S. 2d st C
Stewardson, John L
Stewart, Alexander, 224 S. 5th st 2d
Stewart, Chas., Bricklayer, 37 N. 7th st C
Stewart, Frank, Physician, 113 S. 7th st L
Stewart, Thos. S., Architect, 623 S. 10th st 1st & L
Stockton, Alex. D., Clerk, 510 N. 4th st C
Stockton, Hurley B., Electrotyper, 606 to 614 Sansom st C
Stokes, Samuel E., Machinist, 3001 Chestnut st C
Stout, Watson, Heaters & Ranges, 1208 Ridge av C
Stover, Lewis, Attorney, 522 Walnut st C
Straake, Frederick. Manuf'r, 20 N. 5th st L
Stratton, Matthias, Gas Fitter, 719 Walnut st L
Stratton, Wm., Gas Fitter, 719 Walnut st L
Stratton, Wm. A., Grocer L
Straube, Max, Teacher, 2822 Girard av C
Strawn, Joel W., Chemist, 116 N. Del. av C
Strode, Jos. C., Hydraulic Eng., Phila. Post-office L
Strohm, Samuel D., Dentist, 117 Laurel st C
Stroud, Wm. C.. 2110 Mt. Vernon st 1st
Struthers, J. Strickland, Merchant, 313½ Walnut st L
Sturdivant, Horatio W., Engraver L
Sugden, Samuel D., Machinist 1842 Tulip st C
Sulgar, Abraham, Dry Goods L
Sumner, John, Blacksmith, 531 N. 20th st 2d
Sweatman, V. Clement, Acc'tant, 1508 Green st L
Sweeting, T. Henry, Manuf'r, 206 Walnut Place C

Taber, Geo., Secretary, 233 S. 4th st L
Taggert, Wm., Mech. Eng., 1103 Fairmount av C
Talmage, Eben S., Bookbinder, 114 S. 3d st C
Tasker, Thos. T., 1622 S. 5th st L
Tasker, Thos. T., Jr., Manuf'r, 2020 Walnut st L
Tatham, Benj'n, Manuf'r, 82 Beekman st, N. Y. L
Tatham, Edward, 1114 Spruce st 1st
Tatham, Geo. N., Manuf'r, 1114 Spruce st 2d
Tatham, Geo. N., Jr. 1114 Spruce st 1st
Tatham, Henry B., Jr., 226 S 5th st 1st
Tatham, James, 226 S 5th st 1st
Tatham, Wm. P., manuf'r, 226 S. 5th st 1st & L
Tatham, Wm., Metallurgist, 313 S. Broad st 2d
Taylor, Geo., E., Tin Plate, 301 Branch st C
Taylor, Geo. W., 50 N. 4th st L
Taylor, Henry P., 648 N. 10th st C
Taylor, Stacey, House Carptr., Grier st bel. 13th L
Teal, Peter, Machinist, 12 Morgan st L
Tener, Robt., Coal, 955 N. Front st C
Tennent, John, Stock-maker, Mt. Airy L
Terne, Bruno, Dr., Chemist, 20 S. Delaware av C
Tetlow, Henry, Toilet Soaps, 122 Arch st C
Thackera, B., Manuf'r, 718 Chestnut st C
Theobald, Adam H., Tobacconist, N. E. 7th and Girard av C
Thomas, J. V., Iron Master, Bellefort, Pa. L
Thomas, Lancaster, Apothecary, Broad and Ellsworth sts C
Thomas, Reynold, Clerk, 304 Walnut st C
Thomas, Samuel A., Gas Eng., 420 N. 11th st C
Thompson, Ambrose W. L
Thompson, Chas., T., Draughtsman, 1057 Richmond st 1st
Thompson, David 1st
Thompson, E. O., Tailor, 908 Walnut st C
Thompson, Geo., Manuf'r, 900 Pine st L
Thompson, John J., 2024 Spruce st 1st & L
Thompson, Thos, Stonecutter, 1227 Sp. Garden st L
Thompson, Wm. J 1st
Thomson, E., Chemist, 2134 Fitzwater st C

Thomson, Frederick, Printer, 711 Hoffman st C
Thorn, Fred. G., Architect, 410 Walnut st C
Thorne, Wm. H., Machinist, 21st ab. Market st 2d
Thorpe, Chas. N., Watchcase-maker, Ledger Building C
Thurston, Robt. H., Prof. Mech. Eng., Stevens Institute, Hoboken, N. J. C Elected an Honorary Member Feb. 13th, 1878.
Tibbits, Francis G., Manuf'r, 430 Walnut st C
Tilghman, B. C., Lawyer, 1114 Girard st L
Tilghman, Edward 1st
Tilghman, Richard A., 321 S. 11th st 1st & L
Tiller, Sam'l, Copper-plate Printer, 815 N. 15th st L
Todd, Wm. E., Machinist, 1365 Beach st C
Todd, W. W., 809 N. Delaware av C
Toland, Geo. W., 2039 Pine st L
Towne, Henry R., Stamford, Conn. 1st
Townsend, David, Engineer, 1723 Wallace st 2d
Townsend, E. Y., 218 S. 4th st 1st
Townsend, I., Manufacturer, 329 N. 11th st C
Tracy, R., Watchcase-maker, 104 S. 6th st L
Trautwine, J. C., Civil Eng., 530 N. 6th st L
Trautwine, John C. Jr., Clerk, 1608 Market st C
Troth, Samuel N., Physician, S. W. 7th & Thompson sts 2d
Trotter, George, 218 S. 4th st 1st
Trotter, Wm. H., Merchant, 36 N. Front st C
Trueman, Wm. H., Dentist, 511 Spruce st C
Truman, Alex. S., Hardware, 835 Market st C
Tucker, Christopher, 1441 N. 17th st C
Turnbull, Lawrence, Physician, 1208 Spruce st L
Turner, Ernest, Surveyor; 141 N. 20th st 1st
Turnpenny, Jos. C., Druggist, 813 Spruce st L
Tweedale, Thos., Moulder, 522 N. 6th st C

Uhlinger, W. P., Machinist, 22 E. Canal st C
Ulmer, Charles B., 1622 Swain st 2d
Unger, John F., Civil Eng., 431 Master st C
Ustick, Stephen, Machinist, 134 S. 4th st C

Vail, Hugh D., 1927 Mt. Vernon st 2d
Van Artsdalen, Jas. T., Engraver L
Vance, James M., Hardware, 1629 Girard av L
Vanhorne, M. K., Carver, 186 S. 11th st L
Vaux, George, 1715 Arch st C
Vaux, Wm. S., 1702 Arch st L
Voight, Charles V., M.D., 331 Lombard st C
Voorhees, Philip K., Lawyer, No. 11 Astor House, N. Y. C

Wagner, H. D., Mech. Eng'r, 1016 Filbert st C
Wagner, Wm., 17th & Montgomery av L
Walanta, Edmund, 1616 Sydenham st 2d
Walborn, Cornelius A., Middleton, Pa. L
Walder, John H., Mechanical Engineer, Germantown, Pa. L
Wallace, John Wm., 728 Spruce st C
Wallace, Shippen, Chemist, 113 Walnut st C
Walsh, Moses, Chemist, 921 Parrish st C
Walther, Fred'k, Optician, 703 Thompson st C
Walter, Thos., Manuf'r, 1017 Market st C
Walter, Thos. U., Architect, 720 N. Broad st L
Walton, C., Hardware Dealer, 625 Market st C
Walton, C. W., Manufacturer, 413 Arch st C
Walton, Joseph J., Optician, 924 Chestnut st C
Wanich, Alex., Machinist, 1410 Hanover st 2d
Warder, J. H., Engineer, Indianapolis, Ind. L
Warder, R. P., Prof. Haverford College, Pa. C
Wardle, Thomas, 465 Arch st L
Ware, Lewis S., Engineer, St. George's Hotel C
Warren, E. B., Roofer, 228½ Walnut st C
Warren, Samuel D., Merchant, 17 State st, Boston, Mass. L
Warrington, James, Merchant, Camden, N. J. L
Watson, Andrew, Machinist, 538 E. Cumberland st C
Watts, Geo. W., Draughtsman, 1057 Richmond st 2d
Way, Albert M., Engineer, 6 Reed st C
Weaver, John J., Plumber, 7th & Filbert sts C
Webb, S. Wm. F., Clerk, 16 Logan Square L
Webster, George S., Engineer, Kensington and Indiana avs C
Weidner, Chas. A., Chester, Pa. 2d
Weightman, Wm, Chemist, 9th & Parrish sts L
Welsh, Ashbel, C.E., Lambertsville, N. J. L
Welsh, Chas., Engraver, 1617 Mt. Vernon st L
Welsh, John, Merchant, 1034 Spruce st 1st & L
Welsh, Samuel, 304 Walnut st 1st
Wenderoth, Joseph A., Coal Dealer, 1818 Washington av C
Wensley, James, Shoe Fitter, 417 Arch st C
West, Henry F., Mfr., Gloucester, N. J. C
West, John, Mechanical Engineer, Bethlehem, Pa. L
West, Thos., Smelter, 1907 Frankford av C
Westermayer, Adolph, Machinist, U. S. Mint C
Westinghouse, Geo., Jr., Pittsburgh, Pa. 1st
Wetherill, Robt., Machinist, Chester, Pa. 1st
Wharton, Jos., Nickel Works, 28 S. 3d st C
Wharton, Jos. S. L., Iron Founder, 15th & Wood sts C
Wharton, Wm., Jr., R. R. Builder, 1506 Pine st C
Wharton, W. Rodman, Engineer, 2107 De Lancey Place C
Whartenby, Thos. L
Wheeler, Jos. K., 2026 Chestnut st L
Whelan, Chas. S., 309 Walnut st 2d
White, Chas. H., Cabinet Maker, 723 S. 10th st L
Whitney, Geo., Engineer, 16th & Callowhill sts L
Whitney, Jas. S., Mfr., 16th & Callowhill sts L
Whitney, Jno. R., Mfr., 16th & Callowhill sts L
Whitney, Thos. J., Sewing Mach., 1530 N. 17th C
Wickersham, C., Attorney at Law, 124 S. 6th st L
Wickersham, Morris S., 247 S. 3d st L
Wiegand, Jno., Jr., 45th st & Osage av L
Wiegand, S. Lloyd, Engineer, 144 S. 6th st L
Wiegand, Thos. S., Apothecary, 528 Arch st C
Wilcocks, A., Physician, 2133 Walnut st 2d
Wilcox, Austin O., cor. Broad and Parrish sts L
Wild, Chas. E., Sup't Print Works, Chester, Pa. C
Wildberger, P. J., Manuf'r, 253 N. 3d st C

Wiler, Wm., 225 S. 5th st 2d
Wilhelm, Chas., Lamp Maker, 919 Race st L
Wilkins, E. W., Clerk, 114 S. 2d C
Wilkinson, Geo. P., Chemist, 339 Walnut st C
Willcox, Jos., 1624 Spruce st C
Williams, Albert B., C.E., 617 Franklin st C
Williams, Chas. B. L
Williams, Chas. B., Merchant, 627 Market st C
Williams, E. D., Lawyer, 457 Marshall st C
Williams, Edward H., 500 N. Broad st C
Williams, Henry S., Mathematical Depot, 924 Chestnut st C
Williams, Isaac S., Tin Plate Worker, 728 Market st C
Williamson, John, Lumber Merchant, 45th st and Lancaster av L
Williamson, Wm. C., Eng'r, Richmond and York sts C
Willitts, Alfred, Furniture, Holmesburg, Pa. L
Willits, Jas., Bricklayer, 1629 Mt. Vernon st L
Willits, T., Merchant, 152 N. 4th st C
Wilson, C. G., Hardware, 508 Commerce st 2d
Wilson, E. H., Clerk, 1500 Green st 2d
Wilson, E. L., Publisher, 116 N. 7th st 2d
Wilson, H. A., 512 Marshall st 1st
Wilson, H. H., 512 Marshall st 1st
Wilson, J. A., Civil Eng., 410 Walnut st L
Wilson, J. L., Civil Eng., 512 Marshall st 1st
Wilson, Jos. M., Chief Eng., 410 Walnut st L
Wilson, O. H., Merchant, 215 N. Water st L
Wilson, W., Manufac. Paper Hangings, 18th st and Washington av C
Wilson, W. C., Paints, 105 S. Front st 2d
Wilson, W. H., Civil Eng., 233 S. 4th st L
Wilson, Wm. L., Manufacturer, 11 S. 7th st C
Wiltberger, H. A., Bookkeeper, 3947 Market st L
Windrim, Jas. H., 219 S. 6th st 1st
Winkler, Gustavus R., C. E., Williamsport, Pa. C
Winsor, H., Merchant, 338 S. Delaware av C
Wolbold, Henry, Shoe Manf., 1817 N. 6th st C
Wolf, Henry R., Tobacco, 144 N. 13th st C
Womrath, F. K., Furrier, 710 Arch st C
Wood, A., Iron Manufacturer, 1525 Arch st L
Wood, A., Jr., Conshohocken, Pa. L
Wood, Geo. R., 218 S. 4th st 1st
Wood, H. C., Merchant, 612 Race st L
Wood, H., Manufacturer, Conshohocken, Pa. L
Wood, J. T., 8th and Cherry sts., Camden. 2d
Wood, Rob't, Ornamental Iron, 1136 Ridge av L
Wood, T., Manufacturer, 1836 Green st L
Wood, T., Machinist, 2106 Wood st C
Wood, W., Manufacturer, 400 Chestnut st 1st
Wood, W. W. W., Eng. in Chief, U. S. N., 108 Walnut st L
Woods, J., Nashville, Tenn. L
Woolverton, John P., Lumber, 1151 Beach st C
Wright, J. K., Oil Silk Mfr., 2322 Green st L
Wyckoff, E. S., Physician, 6th and Arch sts C

Yarnall, Hibbert, Builder, 21 N. 7th st C
Yarnall, R. 2d
Yeager, John C. L
Young, Lewis T., Salesman, 700 Passyunk av C
Young, Richard, Distiller, Morton, Del. co., Pa. L

Zentmayer, Chas., Optician, 147 S. 4th st C
Zentmayer, Jos., Optician, 147 S. 4th st C
Ziegler, Geo. J., M. D., 128 S. 15th st L
Zoellner, Jos., Doctor, 342 N. 5th st 2d
Zook, J. M., Bookkeeper, 1330 Buttonwood st C
Zorns, Chalkley S., Milk Dealer, 1407 Frankford av C

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LOCOMOTIVE SPARK ARRESTERS.

By J. SNOWDEN BELL.

Read before the Franklin Institute at its meeting, Dec. 17th, 1879.

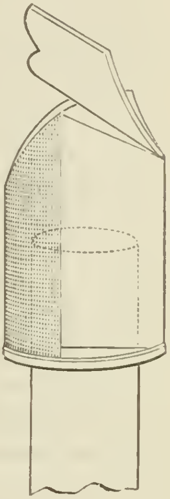
The spark arrester, although one of the earliest of the numerous improvements which have contributed to the advancement of American locomotive engineering, has, as yet, failed to attain a degree of perfection commensurate with that of many constructive details of later origin. While from its earliest period to the present it has received continued attention, and has probably been the subject of more experiment and inventive effort than any other adjunct of the locomotive, the variations in the present practice, which will be obvious to even an unskilled observer, show clearly that the standard has not yet been arrived at. The boilers, frames, cylinder attachment and valve gearing of different builders have been reduced to uniformity in all substantial particulars, but there is a considerable range of difference in the construction of spark arresters.

As preliminary to a review of the history and present development of locomotive spark arresters it may be remarked, that to constitute a *perfect* one, there would be required a device which would offer no impediment to the draught, and at the same time completely bar the escape of unconsumed fuel from the stack. This has never yet been produced, and so far as the present system of locomotive boilers is concerned, doubtless never will be, the conditions being too directly at variance to render it possible for both of them to be satisfactorily complied with. Comparatively few of the results of the efforts made in this direction have survived the tests of practical operation, and it cannot be said of any of them that it is entirely free from objection, or so nearly adapted to the requirements of successful performance as to either merit or receive general acceptance as an approximately perfect apparatus.

The spark arrester is peculiarly an American institution, and possesses but little practical value beyond that derived from American practice. Nearly twenty years ago a suit was brought against M. W. Baldwin & Co., the Philadelphia locomotive builders, by David Matthew, for infringement of patents granted him for spark arresters, and as a part of their defence, Messrs. Baldwin & Co. prepared a drawing showing 57 different forms of locomotive stacks and spark arresters which had been used or patented prior to 1858. This drawing, which it is believed has never been published, fully exemplifies the state of the art up to and at that time, and although, owing to the fact that the suit was not prosecuted, the dates of the different constructions shown were not authenticated by testimony, it will be found to possess much interest for those who may desire to investigate early practice in this direction.

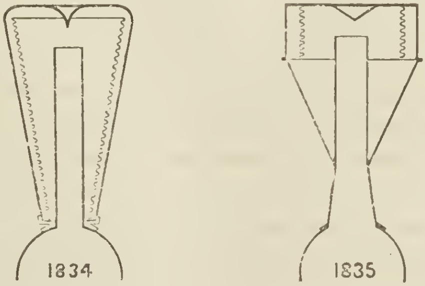
The late Zerah Colburn, writing in 1860, says that the necessity for spark arresters arose with the introduction of wood burning locomotives in 1830, and it is probable that about that time they were first applied, in the form of a wire netting cap placed over the top of the smoke stack. The earliest record which we have been able to discover is the U. S. patent granted to James P. Espy, of Philadelphia, June 29th, 1833, a description and illustration of which, accompanied by certificates of its successful performance, may be found in the JOURNAL OF THE FRANKLIN INSTITUTE, vol. 12, new series, 1833, pp. 418-421. Espy's "draft generating chimney cap," as he termed it, was designed for steamboats as well as locomotives, and was merely a cap pointed or inclined at its front end and kept to the wind by a vane, in the manner of an ordinary chimney cap; its opening was covered by a sheet of fine wire gauze. Espy's cap is shown in Fig. 1. The specification states that it "affords a very free egress to the gases whilst it completely stops the sparks," and the engineer of Mr. Baldwin' locomotive engine (on the Philadelphia and Germantown Railroad) certifies that "with a wire gauze so fine that the head of a pin could not go through the meshes, which was quite too fine, it effectually stopped the sparks without diminishing the draft, and in some cases it even increased it, as by opening the door to put in wood the flame did not come out as it did previously in similar circumstances." Notwithstanding these remarkable statements as to its virtues, which, upon this showing, were certainly very much superior to those of any we now know of, Espy's draft cap had but a brief existence, and is not even honored with a position in the Baldwin drawing before referred to.

Fig. 1.



Succeeding Espy's will be found several patented inventions, dating from 1834 to 1836, none of which came into use to any extent nor possess points that have been embodied in later practice. Passing these as merely unsuccessful speculations, we find the elements of the type of spark arresters which has met with most general acceptance in the United States, in the so-called "bonnet pipe," in which an inverted cone, turned downwards at its outer edge and placed over the mouth of the stack, deflected the sparks and cinders into a surrounding casing, while the smoke and gases escaped through a wire netting or "bonnet," covering the wide top of the outer casing. The invention of the bonnet pipe is claimed by Colburn for Wm. T. James, of New York, in an engine placed by the latter on the Baltimore and

Fig. 2.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Ohio Railroad in 1833 (*Recent Practice in the Locomotive Engine*, p. 59), but, as exhibited in the Baldwin drawing, dates from 1834, and is to be credited to Isaac Dripps, then master mechanic of the Camden and Amboy Railroad; Nos. 8 and 9 of the drawing, which are here reproduced in Fig. 2, each showing a crude, although not impracticable, form of the combination of the deflector, netting, inside pipe and outer casing. Colburn (*The Engineer*, Philadelphia, 1860, p. 137) refers to "the cone and netting pipe made by Isaac Dripps in 1835, and patented by him in 1837." The latter statement is, however, erroneous, as no spark arrester was patented by Mr. Dripps at that or any other time. Different forms of the bonnet pipe were patented by Duff (1837) and Briscoe (1838), and in *Locomotives and Locomotive Building*, published by the Rogers Locomotive and Machine Works, 1876, it is stated (p. 9), referring to the engine "Sandusky," built by Rogers, Ketchum & Grosvenor, and first run October 6th, 1837: "the smoke pipe was of the bonnet kind, having a deflecting cone curled over at the edges in its centre, so as to deflect the sparks downward, and thus prevent their passing through the wire bonnet, as well as preventing the bonnets wearing out too fast." Numerous unimportant variations of the bonnet pipe succeeded the original examples of Dripps and Rogers, and it reached its latest form, known as the "Yankee" stack, about 1841. As exemplified in the Mason engines of 1857 (Fig. 3), it is still extensively used for wood burning engines, but in bituminous coal burners has given place generally to the modification usually termed the "diamond" stack (Fig. 4), in which the cone and netting are retained and the outer casing reduced in dimensions. The diamond stack, with various modifications of detail, is in use to a greater extent than any other at the present time.

A form of the bonnet pipe patented in the United States by W. T. James, April 13th, 1838, having a series of curved discharge passages under the central deflector (afterwards embodied in the French and Baird stack, 1842, and the Radley and Hunter, 1850), was adopted by constructors in Austria and Germany, and is shown in the drawings of the engines offered for competition in the experiments upon the Semmering incline of the Vienna and Trieste Railway, in 1852 (*Die Lokomotive der Staats Eisenbahn über den Semmering*, Wien, 1854, Bl. XVI, XXI). In European treatises of much later date than the James patent, it will be found described as a German invention, and is termed "Klein's apparatus" (*appareil de Klein*). It was, moreover, patented in England by one Charles Cowper, in 1851, No. 13,705.

Fig. 3.

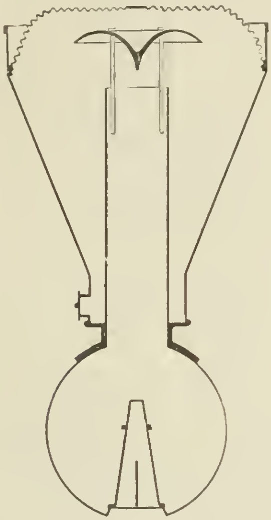
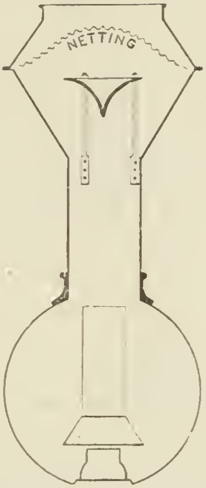


Fig. 4.



The principle of the bonnet pipe was preserved and employed under various modifications, from its conception by Dripps, in 1834, to the diamond stack of to-day, and among its various forms, one which found considerable favor, and is still in use, is that designed by John P. Laird for the Pennsylvania Railroad about 1864 (Fig. 5), in which the reduction of the size of the outer casing appears to be the distinguishing feature.

Returning to the order of dates, the next spark arrester, which, after the invention of the bonnet pipe, appears worthy of notice, is that of William Schultz, of Philadelphia, patented March 31, 1836 (Fig. 6). This may be described as in the form of the present diamond stack inverted, with its deflector removed and the exhaust nozzles passing through the netting. Schultz's stack was used on the Philadelphia and Columbia Railroad, and some of them were to be seen there up to the time that the road came into the possession of the Pennsylvania Railroad Company.

Fig. 5

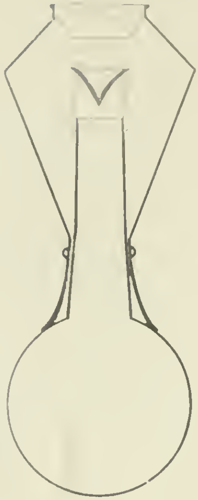
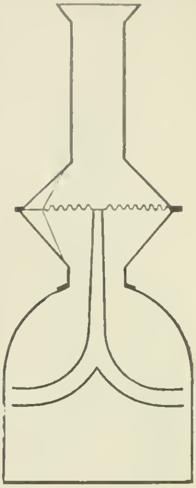


Fig. 6.



Longmire and Brooke, of Philadelphia, in 1840, proposed to prevent the escape of sparks from locomotives by carrying them into the ash pan. Their plan contemplated extending the exhaust pipes *downward* into a flue passing horizontally under the boiler, into or below the ash pan, "so as to cause the sparks, with the waste steam and the gaseous products of combustion, to be discharged into a compartment prepared therefor, or into the ash pit, allowing their final exit to be downwards, or on or towards the ground." It is probably needless to state that if this apparatus worked on paper it would not on a railroad, and it has not, like some other impracticable suggestions, been periodically re-invented. In the latter respect, however, it differed from the "spark extinguisher" of David Ritter, patented November 26, 1840, which is noticed here only for the benefit of the inventor who may be so unfortunate as to develop the idea that he can carry the sparks and cinders through a horizontal pipe leading from the stack over the top of the train and discharge them at the rear end. Numerous patents have been granted since that of Ritter, for inventions embodying the same principle, none of which appear to have made any practical record.

In the Farrand spark arrester, patented August 19, 1873, which is shown in Fig. 7, the cinders are claimed to be separated by curving the top of the stack forward and downward into a chamber from which the smoke and gases escape through two short vertical discharge flues, while the cinders may be returned to the fire box. This, like the Stevens stack of 1876, is substantially a reproduction of the principle of W. S. Montgomery's spark extinguisher, patented July 28, 1838.

Fig. 7.

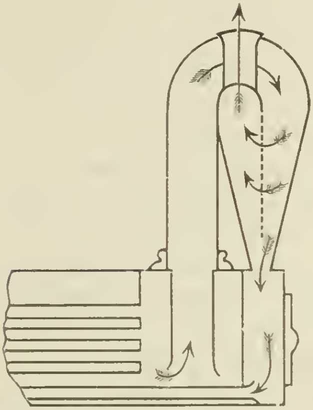
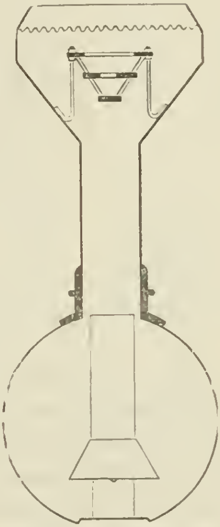


Fig. 8.

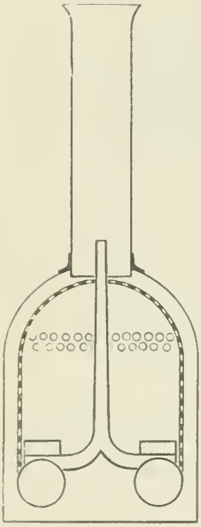


The Hughes spark arrester (Fig. 8), patented September 16, 1873, has been found to work well on anthracite coal burning engines. Its features are a deflector composed of a central disk with two separate rings of greater diameter above it, and an upper supplemental cone which can be adjusted in position to vary the draught.

In each of the several devices thus far referred to it will be noticed that the apparatus by which the sparks and cinders are to be separated from the smoke and gases is located in or connected with the stack. We shall now examine a different class, which, though not of recent origin, has of late years been revived and made the subject of strong claims as to its merit and utility, namely, that in which the separating and arresting apparatus is located either wholly or partially in the smoke box. This we may not unreasonably expect to find as an adjunct to English practice, in which the adoption of American improvements has been more limited and tardy than on the Continent of Europe. The English patents of Samuel Hall, No. 8792, Jan.

14, 1841, and No. 9345, May 9, 1842, show the earliest smoke box deflectors we have been able to discover; the same being in the form of a perforated metallic plate, passing around and above the front end of the tubes, and having the exhaust pipe carried through it into a straight open stack, as shown in Fig. 9. A horizontal perforated deflector placed across the smoke box above the top row of tubes, as used by Hovey and others in the United States in 1863, was patented in England by Wm. Geo. Beattie, March 5, 1864, No. 559.

Fig. 9.

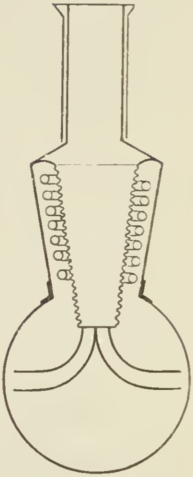


In the Baldwin drawing of 1860, the sketch numbered 45, representing a construction of Eastwick & Harrison, of Philadelphia, dated 1840, shows a cylinder of wire netting connecting the series of separate exhaust nozzles with the bottom of the inside smoke stack, about one-half of the cylinder being located in the smoke box. The usual upper netting or bonnet extends over the top of the outer casing. We can find no record of the performance of this apparatus, which probably failed by reason of offering too great an impediment to the draught.

R. A. Wilder, Engineer and Superintendent of the Mine Hill and Schuylkill Haven Railroad, next appears in this category, as the inventor of a perforated truncated cone of wire netting, extending from the nozzles of the exhaust pipes to a point above the base of the stack, and designed to intercept the sparks and cinders while giving passage to the lighter products. This he patented in 1854, in a combined feed-water heater and spark arrester, which was used on the anthracite coal burning engines of the Mine Hill and Schuylkill Haven and other roads. An illustration and description of the Wilder stack will be found in the JOURNAL OF THE FRANKLIN INSTITUTE, Vol. 33, 3d series, 1857, p. 414, and it is shown in the accompanying Fig. 10, as applied to the Baldwin eight-wheel connected engine, "No, 29," of the Mine Hill road, from an article upon which, by Colburn, in the *Engineer* (Philadelphia), of October 18, 1860, p. 77, we make the following extract, which clearly describes it:

"The smoke box is made of $\frac{3}{8}$-inch iron, and supports a heater, spark arrester and chimney of peculiar construction. A tapering pipe, of coarse wire cloth, 21 inches in diameter at the top, 10 inches diameter at the bottom, and 3 feet 6 inches high, descends 10 inches below the top of the smoke box. The exhaust pipes, with nozzles $3\frac{1}{2}$ inches diameter each, come up to and enter the bottom of this pipe, which is otherwise closed by a plate of perforated iron. The heated air and sparks ascend around this netting pipe, which is surrounded at a distance of 6 inches by an outer casing of stiff iron, and which is thus about 33 inches in diameter at the top, 30 inches high above the smoke box and 24 inches diameter at the bottom. The fine coal carried through the tubes is thrown down by the meshed sides of the netting pipe, the products of combustion passing through and up through a straight open pipe $14\frac{1}{4}$ inches in diameter above. * * * * * The spark arrester has been described, but it should be said that the fine coal and sparks thrown down by the nearly vertical sides of the wire netting pipe, drop through a large opening in the bottom of the smoke box, and into a large iron spark box beneath. This box is cast very heavy, and is really the bed plate of the cylinders, broad flanges on which are strongly bolted to its sides. In the bottom of this spark box or hollow bed plate is a valve through which its contents may be discharged at pleasure upon the track."

Fig. 10.



Wilder's engines had long exhaust pipes and no draft or lift pipes, as in the universal English practice, and a perforated cone, identical in principle with his, was patented in England by W. G. Beattie, March 5th, 1864, No. 559, and C. Moriarty, September 10th, 1864, No. 2219, the latter forming his of "stretcher rods" of iron wire instead of the usual netting. Beattie's cone is shown in Fig. 11.

E. May, of Boston, patented a cylinder of wire netting, extending from the exhaust pipes to the stack, July 28th, 1857, and A. S. Sweet, Jr., of Detroit, patented double cylindrical deflectors on a similar principle June 23d, 1863, after which nothing more appears to have been done in this direction until 1870, when the Wilder perforated cone, "in combination" with the ordinary American draft pipe, used for a long time theretofore with short exhaust nozzles, was again patented in the United States by James Smith, and has been adopted as a standard for their passenger engines by the Pennsylvania Railroad Company, using both anthracite and bituminous coal, and by several other roads burning anthracite exclusively. Fig. 12, from *The Pennsylvania Railroad*, by James Dredge, London, 1879, shows the Smith stack as used on the Pennsylvania Railroad and branches.

Fig. 11.

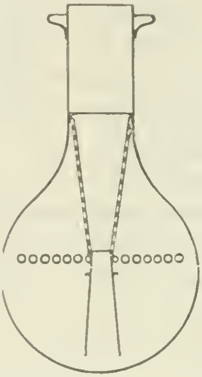
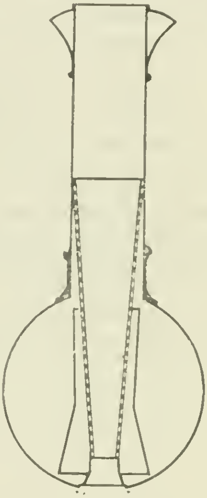


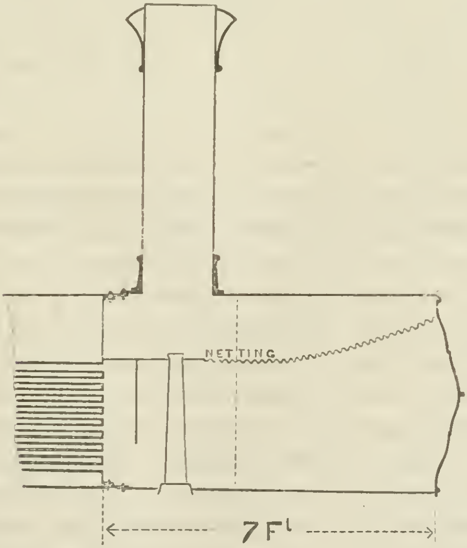
Fig. 12.



The perforated cone possesses, in principle, no advantage over the diamond stack, beyond the possibility of obtaining a larger amount of separating surface, and so far as the use of bituminous coal is concerned, the Smith spark arrester does not, in practice, exhibit any material reduction in the amount of cinders and sparks expelled, as compared with a bonnet or diamond stack of the average construction.

Our history may be closed with a notice of the Hovey spark arrester, the latest form of which has been within a few years past introduced on the New York and New Haven Railroad, and the distinguishing characteristic of which is a longitudinal extension of the smoke box, to form a spark receptacle, and the use of deflectors between the tube ends and lower opening of the stack. A smoke box extended forward of the stack was patented, as a spark arrester, by John Thompson, of Boston, May 29th, 1860, upon the theory that the sparks would "pass out of and beyond the current of smoke, so as to be deposited in the box by the action of gravity and not carried up the chimney." A very brief consultation with any experienced locomotive fireman might have led Mr. Thompson to the knowledge that sparks will not behave in this accommodating manner, and an investigation of authorities on boiler engineering would have taught him the fallacy of increasing the dimensions of the smoke box where economy in the consumption of fuel is to be kept in view. His plan never received acceptation from its manifest impracticability, but an attempt to improve it was made by Jacob Hovey, at the time master mechanic of the Cleveland and Pittsburgh Railroad, who added to the Thompson extended smoke box, horizontal deflectors, placed above the upper row of tubes, patented the arrangement April 7th, 1863, and placed it upon a number of engines on the Cleveland and Pittsburgh Railroad. The accounts of its performance on that road were eminently unsatisfactory, engines failing for steam and smoke boxes sometimes becoming red hot in parts from the ignited cinders with which they were partly filled, and the apparatus was permanently abandoned by the Cleveland and Pittsburgh Railroad. Since the early and unsuccessful efforts of Hovey, the extended smoke box system has, from time to time, been taken up by other parties, and has culminated in the

Fig. 13.



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arrangement adopted by the New York and New Haven Railroad, shown in Fig. 13, in which a vertical sheet iron deflector is placed at a distance of about nine inches in front of the flue head and extends to a point about twelve inches above the bottom of the smoke box. This deflector is perforated only for a short distance above its lower side, and a horizontal imperforate deflector extends from the flue head to a point a few inches in advance of the long exhaust nozzle which passes through it. A sheet of wire netting extends from the front of the horizontal deflector to or near the front end of the smoke box, the interstices of which netting form the exit openings for the products of combustion passing to the stack.

R. Hill, in 1873, patented a vertical imperforate deflector and netting in the ordinary smoke box, and S. A. Hodgman, in 1874, a perforated plate in front of the flue head, with a hinged damper on its lower side. The employment of Hill's deflector, which has been embodied in the extended smoke box arrangement, as shown in Fig. 13, is apparently advantageous, and if such a deflector was combined with a smoke box of normal dimensions and a spark arresting stack, all the benefits of the extended smoke box plan, if any there are, would be retained. Such an arrangement, however, does not appear to have been put in practice, and in the only use that has so far been made of the deflector, its value is practically destroyed by the faultiness of a construction with which it has no legitimate connection.

From the preceding retrospect of the history of the locomotive spark arrester, in which we have attempted to sketch merely a few leading features which have characterized its progress from its primitive form, that of a grating or netting placed over the top of the stack, to the present practice, the latter may be divided into three general classes: the bonnet pipe, as modernized into the diamond stack; the Wilder perforated cone, and the extended smoke box with its inside deflectors. Each of these has its advocates, and each is sufficiently open to objection to demand a continuance of experimental research by designers and constructors of locomotives. The defects of the first two systems are those which are inseparable from the impossibility of reconciling perfectly the two directly conflicting conditions which necessarily obtain in any and every spark arrester, but those of the third embrace in addition a radical error of principle and practical disadvantages which combine to more than neutralize any merit it may be claimed to possess. In the formation of this opinion the writer has been governed as well by the dicta of acknowledged authorities as by his own observation of the operation of the long smoke box, and if the expression of his views should succeed in eliciting evidence that he is incorrect, another step will have been attained towards directing the efforts of locomotive engineers to produce a practically perfect spark arrester, in the channel which leads to success.

The error of principle alluded to lies in *expanding* the capacity of the smoke box, the dimensions of which, in the ordinary construction, are too great. In support of this proposition there can be adduced the opinions of Zerah Colburn and Daniel Kinnear Clark, both of whom were engineers so eminent, as well in practice as in theory, that their writings have received general acceptation as standard authority on questions relating to locomotive engineering. From an article by Colburn, on "Proportions of Locomotive Boilers," published in the JOURNAL OF THE FRANKLIN INSTITUTE, Vol. 27, 3d series, 1854, pp. 194-199, we make the following quotation:

"Another means of improving the working of locomotive boilers is in forming a better connection of the tubes and chimney than is afforded by the ordinary 'smoke box.' The direction of this passage must be eased, *and its contents reduced to the smallest possible extent*. The use to which the upper part of the smoke box is generally placed has prevented the separation of that part from the general contents of this chamber. The steam pipes and throttle box, for the want of a better situation, have been placed here, and often in such a manner as to stand in the way of the draft. A plan which I proposed some time since for the relief of the draft of engines on a line having low bridges, which plan I have lately learned was tried with good results some years since on the Columbia road, but for some reason was not continued in use, was to place a level sheet of iron across the smoke box just above the upper row of tubes. This would reduce the contents of the smoke box and consequently the amount of air to be lifted out. It would allow of extending the chimney downwards, and of thereby increasing the effective length, and also of lowering the blast pipes and substituting blast pressure for blast suction. I look to this plan as one likely to become generally applied."

The views of D. K. Clark are to the same tenor, and he verifies them by results obtained from actual experiment with engines in England. (*Railway Machinery.* London, 1865, p. 137.)

The soundness of the principle enunciated by Colburn, and the adoption of the plan he proposes, are further attested by the French engineers Le Chatelier, Flachat, Petiet and Polonceau. In their treatise, the *Guide du Mécanicien Constructeur et Conducteur de Machines Locomotives*, Paris, 1859, under the head "Boite a fumée" (smoke box), they say, on pages 113 and 114: "The dimensions of the smoke box should be, *on principle*, as limited as possible, for the immediate effect of the draught produced by the exhaust is to dilate the air comprised in its capacity; this rarefaction being operated by reason of the diminution of pressure which is the consequence of the draught, the hot gases which fill the tubes, and after them those which fill the fire box, rush into the smoke box to give place to the fresh air which the difference of pressure causes to pass through the grate and fuel. It is evident that for the same action produced by the exhaust of the steam in the chimney, the dilatation will be as much greater in the smoke box as the volume of the latter is smaller, and as a consequence the suction of air through the furnace will be more energetic. It appears, nevertheless, that there is in practice a limit to this reduction of the dimensions of the smoke box, below which it ceases to be advantageous. One of the best means of causing this reduction consists in placing a horizontal plate above the upper row of tubes and lowering the chimney to this plate, which is fastened by angle iron to the vertical surfaces of the smoke box. (Pl. 9, Fig. 2.) Mr. J. J. Meyer, of Mulhouse, has applied this arrangement since the year 1854 to locomotive engines ordered from him by the Austrian Government, which in its turn has adopted it for the remainder of its stock. Many French constructors have also adopted it. Independently of the reduction of volume, there are many advantages in thus isolating the upper portion of the smoke box from the lower. The chimney is considerably lengthened, and the exhaust pipe shortened, and the joints of the steam pipes are not altered by the action of heat."

A smoke box reduced in dimensions as proposed by Colburn is shown in Plate xliii of *Recent Practice in the Locomotive Engine*, London, 1860, representing a passenger engine built by Sharp, Stewart & Co., Manchester, for the Egyptian Railway.

The authorities cited merit consideration, and it can scarcely be maintained upon mere assertion that the position assumed by them upon this question is an erroneous one, especially as it accords with the universal practice in marine and stationary boilers, as well as with that of all locomotive builders in this country and Europe, except the comparatively small number here who have adopted the extended smoke box arrangement.

The practical disadvantages of the extended smoke box are, in addition to greater cost of construction and maintenance, the increase of weight which it throws upon the truck, and the necessity of cleaning it at the end of the trip. Accurate data as to the percentage of unconsumed coal which passes out of the front end of the tubes of a locomotive cannot probably be obtained, but it is obviously a large one. In a report on the tests of a Baldwin 16×24-inch engine, on the Cincinnati, Hamilton and Dayton Railroad, made by John W. Hill, M.E., and published in the JOURNAL OF THE FRANKLIN INSTITUTE, April and May, 1879, Mr. Hill states that of the coal charged per foot of grate not less than *twenty* per cent. must have been blown unconsumed out of the stack, and adds: "The facility with which a locomotive boiler operating under a strong blast can distribute unburnt coal along the track is well known, but it is doubtful if the percentage of coal thus disposed of is equally well known. Under the ordinary conditions of locomotive performance, with careful firing and regular blast, the loss of coal by this avenue is, in the writer's opinion, rarely less than *five* per cent." As another estimate, it may be added that in the specification of a recent patent to a locomotive builder, the statement is made that there is "a waste of fuel, amounting to nearly fifty-five per cent., caused by the too rapid passage of the products of combustion through the tubes and by the premature escape of unconsumed fuel in the condition of gases and ignited sparks."

Whatever the actual average percentage may be, it is clear that it would be impossible for an extended smoke box, even when exaggerated, as in some instances, to the length of seven feet, to contain all the sparks and cinders which escape from the tubes during the ordinary run of a passenger engine, and therefore they must, with the exception of those which at the commencement of the trip bank up in the front end and are transported uselessly, be driven through the netting and out of the stack. No advantage, either theoretical or practical, appears in this method of expulsion over that practiced with the bonnet pipe or the perforated cone, and the objections, both of principle and in practice, are too undeniable to be explained away by the vague assertion that the arrangement is "cleaner" than the former ones.

If the position herein taken, that the extended smoke box is a departure from sound theory and progressive practice, be a correct one, the length at which strictures upon it have been presented will be neither objectionable nor devoid of value; and, if not, it is evident that the only other systems of spark arresters which still remain to any extent in use, namely, the bonnet pipe and the perforated cone, should be relegated to the past, and the improvement of the extended smoke box arrangement be recognized as the single avenue to success for all those whose endeavors are directed towards the perfection of this department of locomotive engineering.

Magnesium Steel.—A half per cent. of magnesium changes coarse-grained into fine-grained steel and greatly improves the quality. The magnesium is introduced through an opening in the cover of the crucible, after inserting some small bits of charcoal, in order to remove the free oxygen. Without this precaution there would be danger of an explosion.—*Ber. der Chem. Gesell.* C.

Twin Locomotives for a Portuguese Tramway.—The tramway from Villa Real to Villa Regoa has grades of ·08 (422·4 ft. per mile). Mule service, which was first intended, being deemed insufficient, it was decided to try a new plan, with special engines from Winterthur. There are two locomotives, with a metallic frame-work suspended between them, on which rests a platform for the freight. The frame is made of iron beams, 11·5 metres (17·5 yds.) long, and ·45 metre (1·476 ft.) high, fastened at their ends to the two locomotives and firmly joined together. The platform is 8·1 m. (26·575 ft.) long and 1·9 m. (6.234 ft.) wide, 0·67 m. (2·198 ft.) above the rails, weighing 3·3 tons and with a carrying capacity of 15 tons. The locomotives have six coupled wheels, so united to the frame-work as to permit an easy passage over the abrupt curves, many of which have a radius not exceeding 25 metres (27·34 yds.) Air-brakes are attached to the ordinary brakes, for greater security.—*Ann. des Ponts et Chauss.* C.

STANDARD SIZES IN CYLINDRICAL FITTING.

By George Richards.

Read before the Franklin Institute at its meeting Dec. 17th, 1879.

At previous meetings the writer has had the pleasure of presenting before the members of the Institute, descriptions and examples of the system of standard gauges which is being advocated as a means of cheapening the cost of producing machine parts, based upon a uniformity of sizes and interchange of like parts.

Since that time the adoption of such gauges, for a long time considered problematical, has fully equaled the most sanguine expectations, and to the present time more than five thousand of the different forms of standard gauges being made, have been adópted by various shops in this country and in England. It is a pleasure to refer also to measuring machines, an inplement that was unknown in a tool room in this country, so far as the writer is aware, until a few months ago. The twenty-eighth machine is now in progress. A very fine example is presented this evening, just completed for one of the government arsenals. The readings are to the one ten thousandth part of an inch, but variations to the one hundred thousandth part of an inch can be indicated by the machine.

It will be noticed that the machine is arranged with two screws, one for measuring, the other for approximate adjustment in setting the points to standard length bars. The measuring points, which in this machine are in line with the screws, are made in two forms—with spherical and flat points, one set of each being used at a time.

The error in the aggregate and relative pitch of the measuring screw is provided for by the improved methods presented before the meeting a short time since. The screw is immersed in oil to maintain a uniform temperature throughout its length and to avoid particles of dust accumulating on its surface. The machine receives pieces to twenty-four inches in length and to four inches in diameter.

Referring again to the increased use of standard gauges: it seems now to be generally conceded that these implements are no longer to be regarded as a luxury, but an essential part of an equipment for manufacturing machines. Their low price, together with the advantage gained by their use, being more generally understood, will account for this.

Until recently the writer had only engaged his attention with the means of establishing sizes and testing the accuracy of finished parts, but since a source of trouble has arisen in many cases where it was assumed that the possession of standard gauges alone accomplished the desired results. Some farther means of maintaining the sizes seems to be called for.

Every one at all acquainted with shop manipulation, is fully aware of the fact, that before much can be accomplished in the right direction, the holes in the various parts of machines must be finished with some degree of uniformity, to permit of gauges and proper mandrels being used to advantage.

Having been obliged from circumstances to base most of the precedents in this manufacture upon the English system of work, in which standard gauges have for many years been very generally employed, the fact was partly overlooked, that in their practice holes were bored to size, while here reaming tools were almost universally adopted.

To explain the cause of the difficulties which necessarily arose where reamers of the usual type and gauges were used together, attention is called to an example of such a reamer. It consists of a piece of hardened steel with cutting edges about one-half its length, while the other is of cylindrical form (called generally the "shank"), serving in most cases as an extension or handle to reach through deep holes. The cutting edges are ground to finish a hole to standard size when the implement is new. It is no doubt intended that the shank shall be a guide for the cutting edges, after they are fully entered in the hole being reamed, but it will be readily understood that the cutting edges being continually subject to wear, that to make a commercial success of such a reamer, the shank must be small enough to pass through the hole made by it, without reference to the amount of wear that may occur from continued use.

From this it will be seen that such an implement, without any means of maintaining its original size, can have no reference to standard sizes, except when first used. As the holes made in this way gradually diminish in size, the gauges will not enter the holes, the diameter of cylindrical pieces must also be reduced, and proper mandrels of steel cannot well be employed. The results will, in most cases, be a worse confusion than if no system were attempted at all.

It is of course suggested that such reamers be annealed, reset, hardened and ground; as special skill is required for these operations, they rarely receive such treatment, but as many here can testify, are instead reduced to another size.

For these reasons, it has become necessary to supplement the standard gauges with some implement to produce holes to uniform sizes, and the manufacture of an adjustable reamer of the type at present employed in some of our leading shops, has therefore been entered upon. The form of the reamer is well known in Philadelphia, owing to the extent to which gauges are used here. It consists of a steel body with inserted blades, upon which the cutting edges are formed. The grooves in which the blades are fixed are not parallel with the centre, but at such an angle, that the blades being forced towards the shank, the diameter of the outside of the cutting edges is increased.

Such reamers have from time to time been made, with the usual appliances at their command, by those shops where a system of uniform sizes has been adopted, and have no doubt formed the principal means of maintaining such a system after being begun.

The feature of adjusting the size of a reamer as it wears, brings an entirely new set of conditions to bear on the matter (when compared with the solid ones). It permits of an uniform difference being constantly maintained between the diameter of the cutting edges and the shank. In this case, the shank can be utilized as a means of guiding the cutting edges, to insure straight holes being formed, and still farther form a means of determining the wear to be permitted, as it becomes a check to the use of the reamer when it requires readjustment.

Inasmuch as different grades of fitting will allow of more or less variation in the holes, this limit of accuracy, as it may be called, can be regulated with some degree of certainty. This matter will be dealt with farther on. Attention is called to the general plan of the reamer as an example of fitting and accurate workmanship. It becomes an example of the results possible in producing duplicate parts with accurate means of measuring, in connection with tools made to standard sizes. This form of reamer has always been considered difficult to make, owing to the nature of the fits, but with a view of reducing the cost of them, to allow of their being generally used instead of the solid reamers, it was necessary to base their manufacture upon milling the dovetail slots uniform in size, and producing the blades without reference to their final disposition in any one reamer. The blades are fitted to drive tightly, so as not to be altered in position by any rough usage they may be subjected to. The blades being interchangeable, they can be renewed when worn to the limits of end adjustment. The plan of holding the blade by tight fitting has an object, in preventing the size of the reamer being tampered with by unprincipled workmen, and to insure that it is altered only when worn sufficient to require re-adjustment. Messrs. Wm. Sellers & Co., of this city, have adopted a very good plan in their reamers for this purpose. The blades are driven out from the shank to expand the size. The blades are then ground "flush" with the ends of the stock, showing at a glance if the blades occupy their proper position. This plan, however, presents some difficulties in the manufacture of the reamers that overbalances this advantage; any *convenient* method of adjusting the blades would thus seem a detriment.

It might be explained, that in perfecting mechanism to insure this interchange of parts, an equal number, if not more, difficulties have been encountered than in the making of the gauges. The work is required to be uniform, to about the one five-thousandth part of an inch, which is comparatively a much closer degree of accuracy, where results are based on the maintenance of cutting tools, than in the gauges, where the sizes are obtained by grinding and many tests being made.

In beginning the making of cutting tools to be used in finishing working parts of machines, a step was taken outside the province of gauge making, which had only been directed to furnishing standards to make work to, leaving it to the discretion of the user to determine how the finished parts should fit with the gauges. There had always been some misgivings about this matter, from noticing results after standard gauges were employed, and upon further inquiry, quite a difference of opinion was found to exist. Research was at once begun, to arrive at some definite conclusions, and it is hoped no egotism will be attributed to the writer, when it is explained, that it was assumed whatever such inquiry might determine, those adapting standard gauges would, to a certain extent, be compelled to accept. As the matter is one of general interest, it has seemed proper to place before you the results of the investsgations, with the reasons for certain plans being adopted in the construction of the adjustable reamers.

The question that has called forth this paper is, what relation shall the sizes of holes in machines bear to standard measurements; or, in other words, shall holes be made above, exactly to, or below standard sizes?

In order to cause the argument to be more readily followed in entering into details, it will be proper to call attention first, to the conditions that must exist in any practical attempt to produce parts exactly similar. Different classes of manufactured products call for more or less uniformity in their parts. The controlling element, in most cases, being the destruction of the cutting edges, coupled with slight inaccuracies in the working details of the mechanism actuating the tools.

There is a defined limit to this matter of making parts duplicate and interchangeable in machines, based upon conditions so numerous that no attempt will be made to point them out here. Even when satisfactory results are arrived at, the sizes of duplicate parts can at best be only an approximation to some arbitrary or standard size, but should at all times be within some defined limits, the degree of accuracy established for the work being an exponent of this.

For example, let us suppose that a variation of one hundredth part of an inch is permissible in a certain class of work; in that case an inch, as expressing a size, could be one inch plus one two-hundredth, or one inch less one two-hundredth part of an inch, and yet be regarded as a duplicate of a standard inch, in that particular instance. In making standard gauges, guaranteed to be uniform to the one ten-thousandth part of an inch, as compared with original standards, the gauge may be larger or smaller than this original to the extent of one twenty-thousandth part of an inch. Were it possible to adjust the gauges to the one-millionth of an inch there would still remain the same conditions, in so far as approximating a uniformity in sizes.

This variation then represents the change which tools may be permitted to undergo and yet remain in use for a specific purpose.

It will now, it is hoped, be granted that it is a matter of much importance to arrive at some very definite conclusions about the relation that the sizes in machine fitting should bear to standard sizes. It has been pointed out, that with proper appliances for making the holes, they become the basis in carrying out a system of uniform sizes. Should the implements for finishing the holes be adjusted at first with an allowance made for their wear, to make the holes larger or exactly to a standard size hole?

The difference in the two cases is more than would at first be imagined, and in actual practice is of sufficient moment to warrant the assertion, that even with similar standards in each shop throughout the country, there cannot be said to exist any uniformity in the sizes of their finished product. The difference in the results will at all times be double the limit of accuracy that is assumed in fitting. In one case a 2-inch hole would at first be $2\frac{1}{100}$ inches and diminish in size to 2 inches, while on the other, it would be either 2 inches or 2 inches less one-hundredth, the difference in comparing the results together, being really one fiftieth of an inch.

It will now be well to consider what should be the proper basis, in attempting to arrive at any definite conclusions on the subject.

Some of the different forms of standard gauges used in determining sizes in fitting are exhibited to assist in the matter.

The nature of the surfaces on a pin and ring gauge permit of their both being very nearly the same size. One-tenthousandths of an inch difference in either would make a marked change in the fit. To illustrate this, an example of two gauges with this difference in size is presented for inspection by the members. It would require perhaps a thousandth of an inch in even good fitting to produce the same apparent change in a shaft and hole.

Inasmuch as the close fitting of gauges cannot be carried into practice for this reason, either the internal or external gauge must be assumed as a shop standard.

Everything pertaining to the duplications of standards requires that the external gauge or a length standard be assumed as a basis. The standard lengths of Great Britain, adopted by our government, are bars with points, the outside dimension being the standard length.

In reproducing duplicates, measuring points are brought in contact with the ends, and the distance between them assumes the form of a gauge for that purpose, but not of a standard length.

Referring now to the interchange of different forms of standard gauges, the length standards are represented by pin gauges, the corrective gauge disks, and the "heel," as it is generally called, of the fixed caliper gauge, while outside measures for transmitting these length are represented by the measuring machine, the ring gauge and the fixed calipers.

The latter implements indicate a standard size plus two contacts, or in the case of the ring, of a continuous contact.

The amount of surface contact becomes of much moment in the fitting of standard gauges, owing to the nature of the surfaces and the density of the material employed. The distance measured between the points of a fixed caliper gauge is less than the internal diameter of a ring gauge indicating a similar size, because of the small amount of surface in contact in the former. Again, the internal diameter of a cast iron ring gauge must be greater than one of hardened steel, each appearing to fit the same over a cylindrical gauge. This difference is even more when both are fitted to a pin gauge of cast iron.

From these few examples it will be understood that the duplication of gauges is based upon assuming outside dimensions as the standard.

For these reasons it has been thought best to recommend that in fitting, the size of the holes should be above standard sizes enough to show a contact with a standard size shaft similar to the apparent fit of the gauges with one another.

To refer again to the variations in duplicating parts, as representing only an approximation at best, the different degrees of fitting must now be brought to bear on the matter.

Even if holes are assumed to be made uniform, the size of cylindrical parts must be varied to produce the different contacts referred to in the gauges.

In practice, fits are divided generally into three kinds: first a driving or forced fit; second a close contact or exact fit, and, third a fit loose enough to permit of the surfaces being lubricated by the ordinary means.

To now bring the three conditions that have been explained together: the standard gauges in their various forms; the variation that must occur from wear of tools to form holes, and the different grades of fits employed in practice, it would appear that to suit these conditions most favorably, the slight variation permissible in the holes, compared with a standard size shaft, should represent the fit described as a close one—neither a loose or forced fit. Compared with the gauges now, this fit would show a similar contact with them, the fixed caliper going easy over the shaft and the "heel" of the gauge entering the hole apparently with a similar contact of the shaft. If the fit were a forced one, the shaft would be larger than the gauge, and if a loose fit, smaller than the gauge. Provided the cylindrical parts of machines were prepared in this manner, without reference to the holes, the variations that must be made in their size to fill the conditions of the different fits, is so much more than the variation that should be permitted in the holes, that practically no difference would be noted, whether the size of the hole is at one extreme or the other.

To again call your attention to the adjustable reamer, as perhaps affording farther explanation: the shanks of the reamers are duplicates of standard cylindrical gauges, while the extreme diameter of the cutting edges is the standard size plus the variation or limit of accuracy assumed in the work.

The shank at once assumes a new condition as a part of the reamer. It can be considered as a guide to insure straight holes, but its most important function is as a check, to limit the use of the reamer when it has diminished from its original size to the smallest diameter that is permitted from the degree of variation assumed in the fitting. Practically, this forms the only safe means of controlling the sizes in a shop, without continued attention on the part of the manager.

Without such an implement, the conditions of fitting referred to would be impossible, and standard gauges could be utilized only to a limited extent in fitting.

Mandrels should receive some attention as having a bearing on the matter. When properly used, they should be divided into two classes, for long or short holes; in one case being made straight about one-half their length, with a taper on the remaining part, in the other with a gradual taper from end to end. One end of them will in either case be to standard size, as the holes cannot be made too small to prevent their being entered.

To conclude by drawing comparisons between the system to be attained by using adjustable reamers, in contrast with what could be accomplished with solid reamers, it might be inferred that an extreme position has been taken in the matter, based upon anticipated pecuniary returns from the sale of such reamers, but as they form the only means of making the gauges practical implements (in which it is assumed you are all interested), coupled with the fact that they must be sold, although much more costly, at about the same prices as solid reamers to induce their use, it is hoped that the spirit in which this subject is treated will be properly understood. The object is only to point out the means which must be employed to reduce the cost of machine fitting by a systematic duplication of parts.

SAWS.

By Robert Grimshaw, Ph.D.

The saw is one of the most ancient, useful and familiar of tools. The generic term applied to a serrated dividing tool is generally understood as applying to a saw for wood, although the implement is used also for bone, stone, metal, ice, etc.* (There is also a familiar limitation to a reciprocating hand tool). The ancient Egyptians, far back in the silent centuries, knew and used this tool, the material being bronze, hardened by an art now lost. The Greeks, masters of many and far-sailing wooden ships for war and exploration, deified the inventor, who comes down to us as Talus or Perdrix. The original saw was, doubtless, a flat notched or jagged piece of metal like a nicked knife blade, having no special form of teeth, but used with a straight reciprocating stroke, and for either ripping or cross cutting. It cut on both strokes. The saws of the stone age had flakes of flint imbedded in a wooden blade and held by means of bitumen. The Mexicans used obsidian for saw teeth. The South Sea Islanders employ sharks' teeth, and the Caribs use notched shells.

The saw is mostly used for converting wood and other materials from original forms, and naturally precedes the plane and other tools, although it follows the ax. It does its work with considerable speed and accuracy. In some elaborate and highly ornamental arts it is nearly the only tool used.

The importance of scientific and economical timber-cutting may be conceded when it is asserted that the annual value of the wood, lumber and timber crop of America is a billion dollars ($1,000,000,000), or four times that of our wheat crop. The immense waste in cutting timber, with the millions of axes now in use, is almost incredible. The tough and knotty timber and chips now wasted in cutting cord wood might be saved by cross cutting with saws into short blocks, say one foot long, making good stove wood.

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* Stone sawing, in the ordinary sense of the word, is not sawing, but abrasion in a narrow line by means of loose sand or iron shot, pressed in by a reciprocating blade, while it is also accomplished by diamonds set in iron blades. So-called "saws" for india-rubber and some of those for cold iron rails are plain unserrated disks, no more to be considered under the head of saws proper than Miss Edgeworth's essay on Irish Bulls among works on Natural History.

It is computed that the saving of timber and time by the scientific use of saws would equal the interest of the United States public debt; to say nothing of lightening the toil of millions of farmers.

As we now know the saw it is either RECIPROCATING or CONTINUOUS in action; the first class having a flat blade and practically *straight edge* and making a plane cut; and the latter being either

(1) a *circular rotating disk*, cutting in a plane and at a right angle to its axis;

(2) *cylindrical*, or barrel-shaped, with a convex edge, cutting parallel to its axis; or

(3) a continuous ribbon or *band*, running on two pulleys and making a plane or curved cut, with a straight edge, parallel to their axes of rotation.

There is a fourth class, or *spiral* saw, composed of segments clamped between plates, and cutting a dovetail joint (Armstrong's patent). The entering segments cut like a circular saw; subsequent segments are flanged—at first slightly, and gradually more and more; these later segments have the cut of a cylinder saw. As the flange wears away by filing, the segments are moved on towards the unflanged end of the spiral.

Between the *Reciprocating Rectilinear* and the *Continuous-acting Curvilinear* saws may be classed the *Chain Saw;* its many varieties having either one or two axes, at right angles to the plane of cut; cutting with either a concave, a convex, or a straight edge, and either reciprocating or continuous in action. It is essentially a saw composed of *links* like a chain, and is a connecting link between the two other classes.

We shall consider these classes in sequence, after having gone into the theory of the shape, disposition and action of saw teeth, as applied to the earliest, simplest and most common class, that with reciprocating rectilinear blade.

The blade of this kind of saw is usually a thin sheet of steel, rolled evenly thick, having the teeth then cut out with a punch; the blade then smithed or pressed perfectly plane or flat; ground, principally crosswise, to perfect the surface and reduce the thickness at the back; the teeth then sharpened and set.

This class of saw has more forms of teeth than any of the others.

Its teeth are formed at greatly varying angles and made to cut either way or both ways; sometimes one series of teeth cuts in one direction and another in the opposite on the same blade. In the first case the effective or cutting stroke is either by pulling or by pushing. The carpenter's saw of the ancient Greeks was a straight frame, with perpendicular teeth, and two-handed—doubtless cutting both ways.

The saws of all Asia do not, and those of ancient Greece did not, employ the *thrust* cut, which gives the straightest cut and the freest from sawdust; but cut on the *back* or pulling stroke. But we shall refer to this subject later on, and consider now the outline of the teeth.

It is necessary to premise that the *pitch* of a tooth means the *angle* of the face up which the shaving ascends; not an *interval*, as with screw threads. Small teeth are counted in *points* to the inch; those of large saws by the space expressed in *inches* or in parts of an inch.

The real angle of a point is found by subtracting its back angle from its front.

The generic angle of saw teeth is 60°; being that of an equilateral or "three-square" file. But this may be variously placed.

In the annexed table of angles and spaces the pitches are classified 15° asunder. Thus, in Fig. 1 D is upright, having no pitch; G is flat, having plenty.

The peg tooth, Fig. 2, has rather more throat room than a \/ tooth (Fig. 3) of ths same width and height, and less than if it were cut deeper, as by the dotted lines, Fig. 4. Being generally more acute than 60° it could not be dressed with either a three-square or a flat file if in \/ shape; as it is, a flat or "mill" file dresses it admirably.

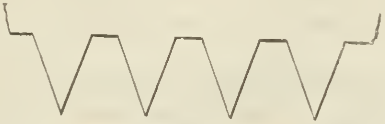


Fig. 2. Peg Tooth.

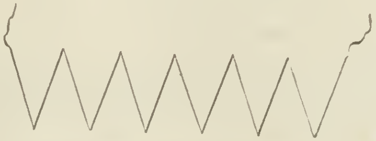
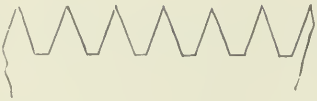
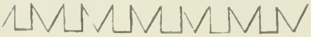
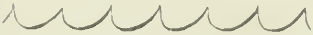
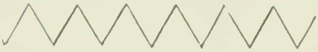
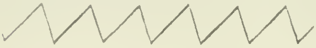
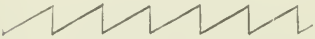
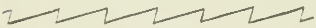
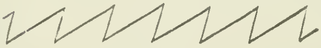
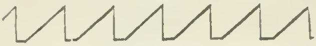
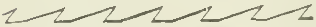
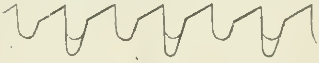
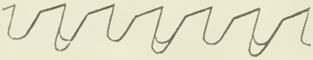
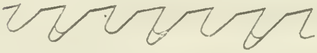
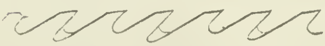


Fig. 3. V Tooth.

Table I.

Simple forms of saw teeth, from Holzapffel.

			Angles.		Ordinary spaces.		
			Face.	Back.	Inches.		
A		Peg; fleam.	110°	70°	$\frac{5}{8}$—$1\frac{1}{4}$		
B		Plain M.	90°	30°	1—$1\frac{1}{4}$		
C		Half Moon.	90°	35°	1—$1\frac{1}{4}$		
D		"Cross-cut"—no pitch.	120°	60°	$\frac{5}{8}$—$1\frac{1}{4}$		
E		Small cross-cut—slight pitch.	105°	45°	$\frac{3}{8}$—1		Also 3 to 60 points.
F		Pruning; ordinary pitch hand-saw; joiners; English cross-cut.	90°	30°	$\frac{3}{8}$—1		
G		Metal; mill saw—soft wood.	75°	15°	$\frac{1}{4}$—$2\frac{1}{2}$		
H		Some circular saws—pit; cross-cut; bath stone.	75°	30°	$\frac{5}{8}$—$1\frac{1}{4}$		
I		Mill.	90°	50°	$\frac{3}{8}$—4		*
J		Circular.	60°	15°	$\frac{5}{8}$—2		
K		Hard wood cross cut.	90°	30°	$\frac{3}{8}$—$3\frac{1}{2}$	Gullet or briar tooth.	
L		Pit; circular.	75°	20°	$\frac{3}{8}$—$3\frac{1}{2}$		
M		Pit; circular.	60°	10°	$\frac{3}{8}$—$3\frac{1}{2}$		
N		Soft wood; ripping.	45°	5°	$\frac{3}{8}$—$3\frac{1}{2}$		

A saw tooth has two functions—*paring* and *scraping*. A *slitting or ripping* saw for wood has the cutting edge about at a right angle to the

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[*] Sometimes each alternate tooth is cut out; then it is "skip-tooth."

fiber of the wood, severing it in one place; the "throat" of the tooth wedging out the piece.

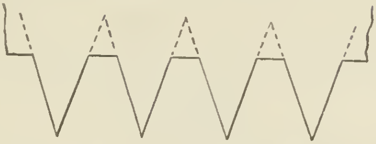


Fig. 4. Peg Tooth.

In a "*cross-cut*" *wood-saw*, also, the cutting edge strikes the fibre at right angles to its length, but severs it on *each side* from the main body, before dislodging it.

In the slitting saw, N, Fig. 1, the "rake" is all in front, where the cutting duty is. In the cross cut, as D, the rake is on the side, for the same reason.

The *length of tooth* depends largely upon the duty required. A long tooth has the demerit of being weak and liable to spring; the merit of giving greater clearance to the sawdust—a specially valuable feature in soft, wet or fibrous woods. It is certain that the throat space in front of each tooth must be sufficient to contain the dust of that tooth from one stroke. If (as in a short tooth) the space be not high enough, that quality can be gained by distance between the teeth. For hard woods, where long teeth are inadmissible, it is best to have short teeth, wide spaced. The deeper the tooth the quicker the saw wears out.

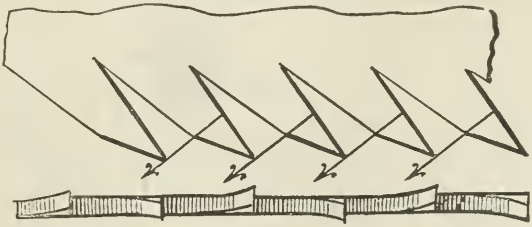


Fig. 5. Great Front Rake.

The greater the feed the deeper the dust chamber required, or else the more teeth needed.

Equal length of teeth is of great importance; as inequality gives the longest teeth the most work and lessens the duty of the saw; giving fewer cutting teeth and dulling them quicker.

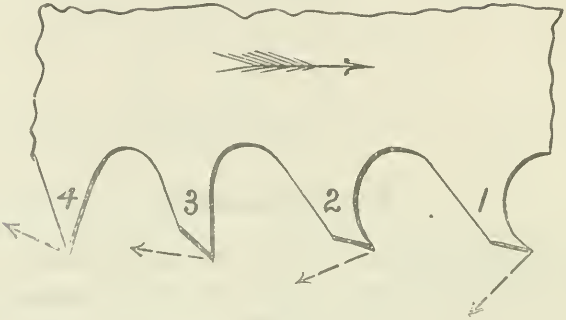


Fig. 6. Showing Various Rakes of Teeth.

Where the teeth are close, the shape of the throat is of special influence.

As regards the tendency of teeth to spring into the work: A form such as Fig. 5, having great front rake, is keen but liable to spring in and break, especially if long and in hard wood. In Fig. 6, tooth 1 has maximum front and minimum back rake. 2 has less hook but more back rake, tending to spring the point down into the wood. 3 has no front rake but considerable back; in 4 the front rake is less than nothing and the keenness is largely dependent on the back edge.

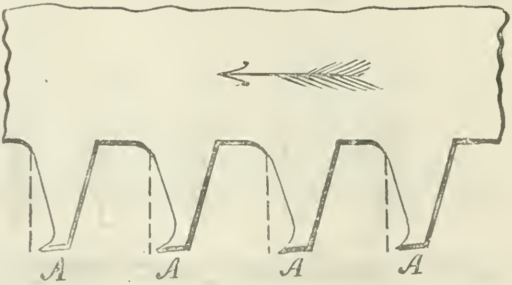


Fig. 7.

Fig. 7 is recommended for heavy saws for general purposes.

This has a rake to the front of the point, and yet the tendency to spring in is compensated by the backward inclination of the whole tooth; and the cutting edge is well supported. There is ample dust room; the rounding corners give strength and immunity from cracking and prevent dust lodging. The backward inclination (as in a planer tool) prevents spring or chatter.

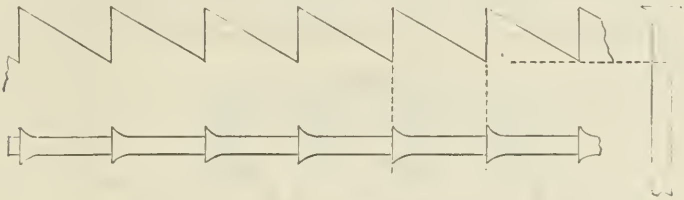


Fig. 8. Spread Set.

We may now consider briefly the question of *Setting*, or bending the teeth laterally, alternately to the right and left; partly with a view to decreasing friction and increasing clearance, and partly to increase the cutting action of the teeth, and make them *cut* rather than *abrade*. (The earlier nations bent the points of a dozen or so of adjacent teeth to one side, and those of the next group to the other.)

"*Swaging*," is another operation having the same objects—giving clearance, preventing binding and heating, and giving increased keenness to the teeth. In this operation each tooth is upset or widened at its point so as to project beyond the blade at each side; differing in this respect from spring setting. See Fig. 8.

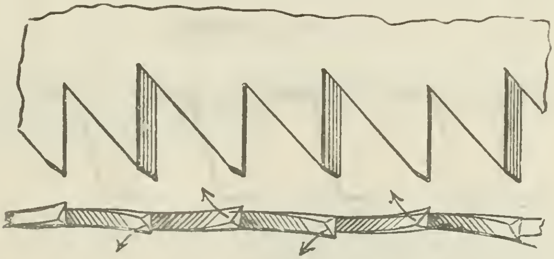


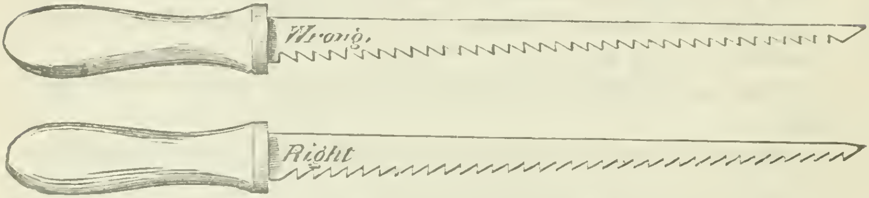
Fig. 9. Spring Set and Side Angle.

Swaging or upsetting is especially beneficial for soft steels and for saws used in soft wood, as it condenses and hardens the metal.

In connection with spring set must be mentioned *side or cross angle*; a bevel or "fleam" given the edges and materially affecting their sharpness and the angle at which they receive the strain of work; as also their retaining their keenness and set.

Fig. 9 represents the magnified teeth of a common hand saw with spring set.

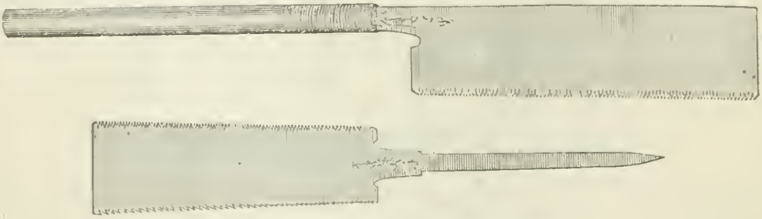
The front edges have a bevel which throws the strain at right angles to the plane of that face (as shown by the arrows). The tendency is to throw the tooth in the *direction* of its set; and any one tooth having more spring set than the others will take undue work; will dull sooner and then spring *away* from its duty, lessening the set and causing friction and heating.



Figs. 10 and 11. Keyhole Saws.

A tooth without fleam or side angle, Fig. 7, has no side strain, other than that due to the spring set. This fleam or cross angle decreases with the thickness of the blade; hence while not fit for heavy saws is proper for hand saws, which, also, have a slow duty. It is better for soft woods, which are free from knots, than for hemlock or spruce, the hard knots of which would break fleamed teeth.

Referring to Fig. 6, tooth 1 would buckle and bend if given any spring set; 3, even if excessively long, would admit of ample.



Figs. 12 and 13. Japanese Saws.

While the teeth remain sharp, spring set tends to increase; when dull, to decrease.

Even setting cannot be over-rated in importance. The tendency of set is to come back. Hence it is sometimes best to first *overset,* then spring back. The setting should not be at a sharp angle but on a *curve.*

Even Swaging is as important as even spring set. A saw with the teeth spread the full width of the kerf will stand more feed than if each alternate tooth be bent for the set. Of the fifteen saws tested at the National Sawing Contest at Cincinnati, 1874, we believe that not one was "spring set."

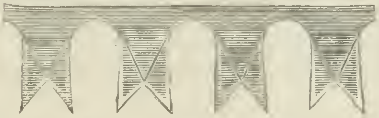


Fig. 14. Boynton's M *Tooth.*

The smaller the saw the greater the advantage of spread over spring set.

The operations of sharpening, setting, and swaging are described in detail in appendices to the present work.

Metals, bone, and hard fine-grained woods, require small teeth with little or no set; ice, and soft coarse-grained woods require them large, widely spaced, acute angled, and much set.

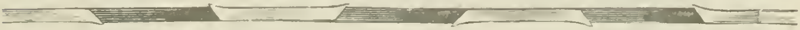


Fig. 15. Front Edge View, showing two Points of M Tooth dressed to cut in line on one side and two the other

Wet wood is softer and more easily cut than dry, but requires a keener and coarser set saw, giving greater waste. *Gummy and resinous materials* and *ivory* require very keen teeth and slow speed, to avoid the dust being softened and made adhesive—which tendency is lessened by greasing the blade.

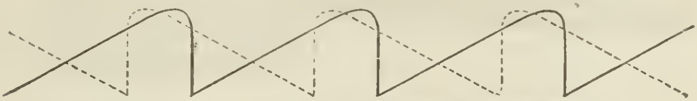


Fig. 16. Showing Space occupied by M *Tooth.*

Table 1 shows the adaptability of various shapes and sizes of teeth to different work.

As regards the question of *pulling or pushing cut*, those of us who have smiled—perhaps audibly—at the Japanese with their backward working saws, should bear one thing in mind before condemning *in toto* the pulling cut—that for keyhole or any other flexible-bladed saws, the backward or pulling cut is the best; and our own usage with that exasperating implement the keyhole saw, is much more ludicrous and unphilosophical than the pulling out of the Niphonese.

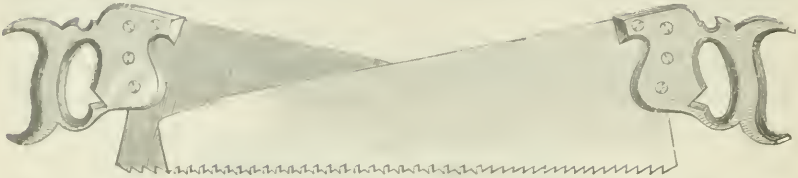


Fig. 17. Double Cutting Action of M *Tooth Hand Saw.*

Figs. 10 and 11* show the common or incorrect, and also the correct mode of placing the teeth of keyhole saws.

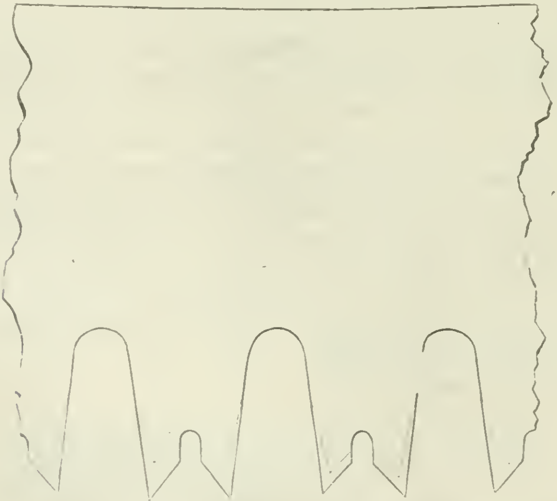


Fig. 18. "Lightning" Teeth.

The Japanese saws are shown in Figs. 12 and 13.

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* From *Polytechnic Review*.

The M tooth may be classed among those having no front rake; but ingeniously arranged so as to cut upon *both* strokes. Upon the same base as the ordinary V tooth are erected, in the same line, two teeth, or a double tooth; an M, in fact, with cutting edges fore and aft; its adjacent neighbor being alike M-shaped and sharpened on all edges, but generally both beveled and set oppositely. It may be said to do the same work, and have the same strength, as a tooth with no front rake; but in the same space arranges for a cut precisely as though the saw had been reversed. The M tooth is sometimes expressed as in Fig. 14. As the /\ angle in the ordinary M would be difficult to keep sharp, and ruinous to file-corners, it is now furnished by Boynton with a gullet, making it very economical of files and ensuring keen edges. The M teeth, which are veritable cutting edges, are edged on an oil-stone, after filing. A variation of the M tooth has its front edges raking backward, while it is still a double tooth; and we may style this the "W tooth."

One important feature in the construction of some hand rip saws and mill saws is that they have coarser teeth at the heel than at the point, so that fine teeth commence and coarse ones finish the cut. Fine teeth cut at the outset more smoothly than coarse ones, but as soon as they become clogged with sawdust they lose their efficiency to a great degree. As this partial clogging becomes more troublesome at the latter end of the stroke this "increment tooth" arrangement (similar in principle to the increment-toothed file so favorably known) brings the larger teeth into play just where they are needed, and while obviating the rank tearing of coarse teeth at the commencement of the cut, reduces the amount of splintering at the bottom of the kerf. This arrangement also makes the saw strongest at the heel and lightest at the point. See Fig. 19.

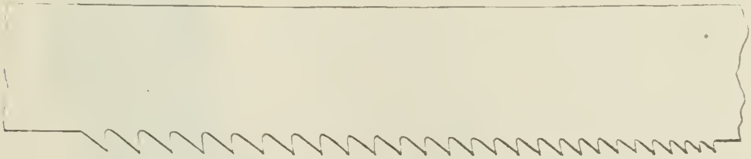

Fig. 19. Andrews' Increment Toothed Mill Saw.

The Reciprocating Rectilinear saw has many varieties. It may be

(1) strained in a frame or sash, and guided on both strokes, while cutting on one only;

(2) guided at both ends but not strained; pull cut;

(3) free at one end, with pull cut;

(4) free at one end, push cut;

(5) free at one end, cutting on both strokes;

(6) strained in a sash, guided on both strokes, and cutting on both;

(7) unguided at either end; handle at each end, and cutting on one stroke;

(8) unguided at either end; handle at each end, cutting on both strokes;

(9) strained by a weight at one end, cutting on one stroke;

(10) strained by a spring at one end;

(11) strained by a spring frame.

The *Single Sash Saw* is now out of date in this country; being rapidly superseded by the mulay and circular. A mulay with the same power applied will do nearly double the quantity of work, owing to its greater lightness and speed.

A single sash saw will make 150 to 200 strokes per minute and cut about $\frac{3}{4}$ inch in hard and 1 inch in soft wood, at each stroke. It is generally 5 to 9 gauge.

Fig. 20 is a form of mill-saw tooth (Hoe & Co.)

But while the single sash saw cannot compete with the circular in speed of cut or quantity of lumber turned out, the *gang* sash, having several blades strained in one frame, has a greater *collective* speed and capacity; and in the form of the "deal-frame" used in England to resaw squared logs, is one of the most effective of all saws; making little kerf, having a high speed, and cutting many boards simultaneously; while gang-sawed lumber brings a higher price than that from circulars.

Fig. 21 shows one of the most improved American gang sash machines. The sash is 38 inches wide and contains 26 saws each $4\frac{1}{2}$ feet long and 9 inches wide, No. 14 gauge; teeth $1\frac{1}{4}$ inches from point to point and the same depth, swaged to cut a kerf but $\frac{5}{32}$ inch wide. The "cant" is from 10 to 25 inches deep, the stroke 19 inches and the speed 225 revolutions (and consequently full cuts) per minute, at a feed varying from $\frac{3}{8}$ to 1 inch each cut, according to the kind of timber. The machine is run by a double belt 20 inches wide over a driving pulley $4\frac{1}{2}$ feet diameter, requiring an engine of 16 inches bore, 20 inches

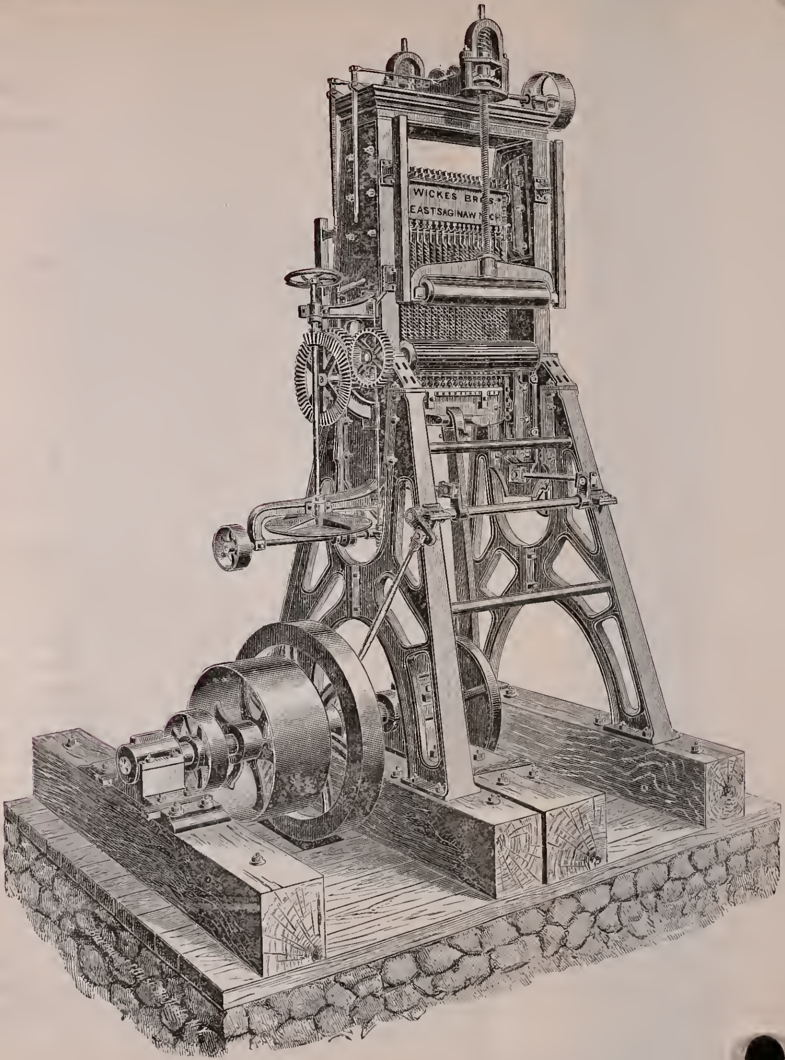

Fig. 21. Wickes Bros.' Iron Frame Gang Sash Saw.

(1)
cuttin
(2)
(3)
(4)
(5)
(6)
(7)
stroke
(8)
stroke
(9)
(10
(11
Th
idly s
power
its gr
A s
about
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Fi
Bu
speed
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ously
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stroke, making 175 revolutions per minute at 60 lbs. pressure. The average capacity is 70 M feet of one inch lumber per day of ten hours —although it may be worked up to 90 M in the same time.

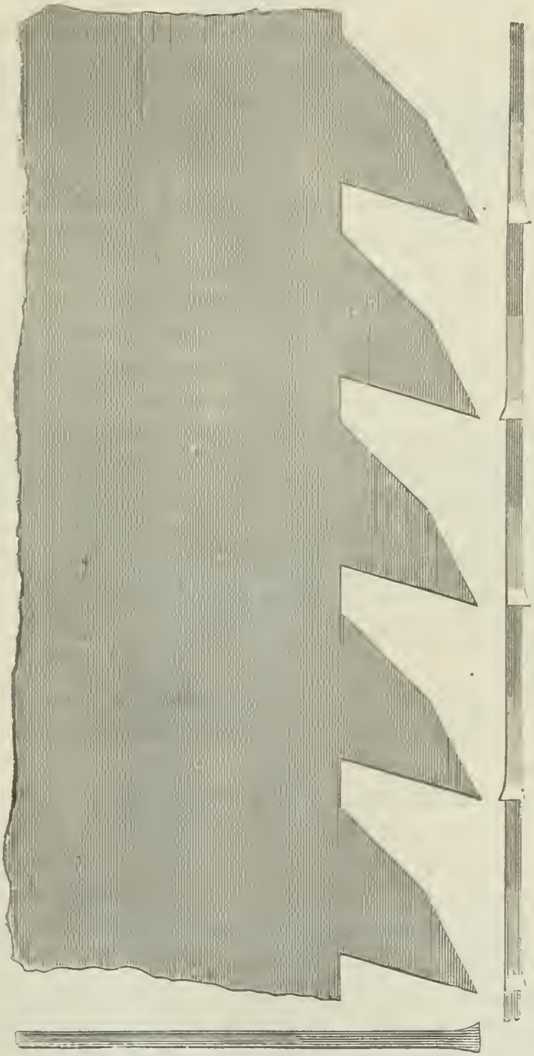


Fig. 20. Mill-Saw Tooth.

The gang sash requires less labor to produce 1000 feet of lumber than the circular does. It works best in connection with a large circular which slabs the large logs into cants for it. The small logs had best be left to a small circular to saw into boards, scantling or other small timber. This gives the gang continuous work on timber worthy of it.

A gang making 240 strokes per minute will take about $\frac{1}{4}$ to $\frac{3}{4}$ inch feed per stroke in 12 inch cants, *i. e.* from 1 to 3 inches per second, according to the timber. The blades are, as a rule, made narrower at the ends than in the center. They are generally 8, 9 and 10 inches wide, from 10 to 16 gauge.

The thinnest saws possible with a fast gang are fifteen gauge.

The principal advantage of the gang is the extreme regularity in thickness of the boards it makes.

The Mulay or Muley Saw (probably named from the German *Mühlsäge, mill-saw*) comes under the head of blades guided at both ends but unstrained. It has a pull cut and very rapid cutting speed, exceeding in this respect the sash saw, which by reason of the inertia of the frame is more limited in speed. Its use is mainly in the Western States of America; and it is in its inception essentially bold and American. There being but little of the blade exposed unguided, its use at high speed is, however, quite safe.

The mulay saw for logs is generally 10 to 12 inches wide and $\frac{1}{4}$ inch thick, and making strokes of 20 to 24 inches at the rate of from 300 to 400 revolutions per minute, giving a cutting speed of about 600 feet per minute.

Mulay saws, when first introduced, were full $\frac{1}{4}$ inch thick. Now they are in use only $\frac{1}{8}$ inch thick—but generally are No. 7 gauge or $\frac{3}{16}$ inch thick.

The length of stroke for some log-cutting mulays 7 feet long is 28 inches; number of strokes 200 to 225 per minute.

The mulay jig (Fig. 22) is perhaps the best for soft wood.

A "smart mulay saw" making 350 to 400 strokes per minute will cut ordinarily $\frac{5}{8}$ inch hard and $\frac{3}{4}$ inch soft wood at each stroke.

Mulays are almost always the same width heel and point. A correspondent writes: "Some years ago, a party in Auburn, N.Y., took out a patent for a mulay mill that used a tapered saw wider at the top than it was at the bottom, but it was a failure."

Mulay gang and mill saws were formerly made thicker on the front edge than on the back; but for some years past they have been given the same thickness on both edges.

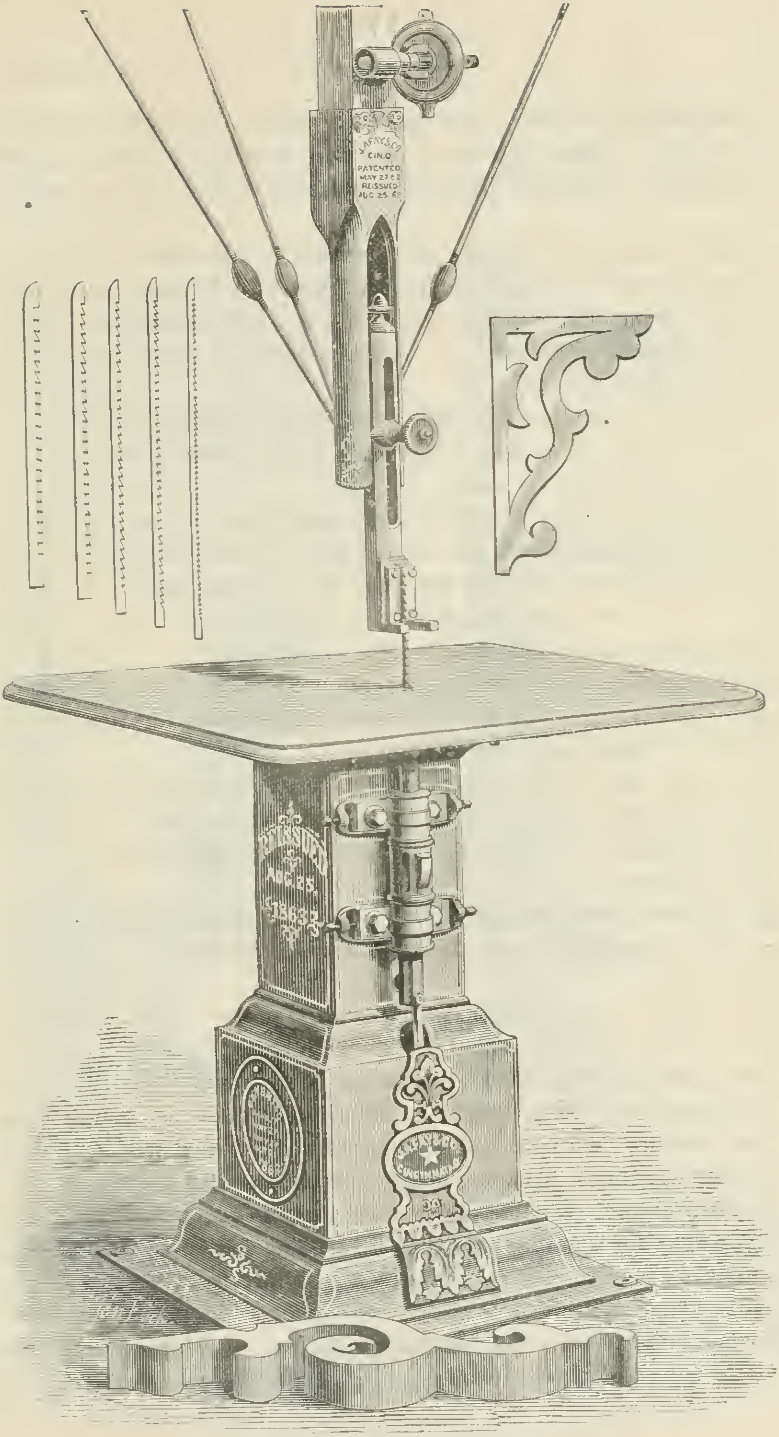


Fig. 22. Fay's Mulay Scroll Saw.

The mulay *scroll* saw shown in Fig. 23 has a 3 inch stroke, and makes 1000 to 1500 revolutions per minute, receiving its power through a 3 inch belt on a pulley 6 inches diameter.

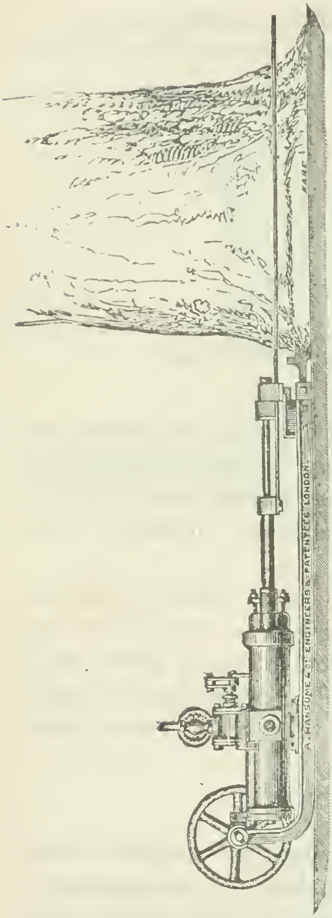

A. RANSOME & CO. ENGINEERS & PATENTEES LONDON.

Fig. 23. Ransome's Tree Feller in Operation.

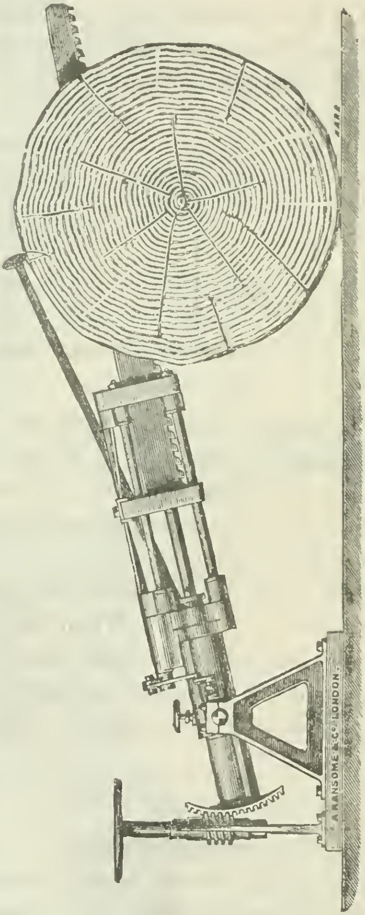

A. RANSOME & CO. LONDON.

Fig. 24. Ransome's Tree Feller as a Cross-cut.

The Drag Saw, as its name implies, cuts on the pulling stroke. It is unstrained and unguided at the free end; and is, in fact, the Japanese hand saw, power driven and guided at the butt. Its stiffness is of course greater than that of a mulay of the same thickness; and it may be made thinner for the same duty. Its use is mostly limited to cross cutting felled logs and ship timbers; though more recently there has been brought out by A. Ransome & Co., London, England, an admirable horizontal adaptation of it to felling trees. (Figs. 23 and 24.)

The butting or drag saw is 7 to 8 inches wide at butt, 5 to 6 inches at point, and 10 gauge.

It is given mill teeth if intended to be used as a drag saw proper—that is, cutting on the pull stroke only; but if intended to cut on both strokes, it is given cross-cut teeth.

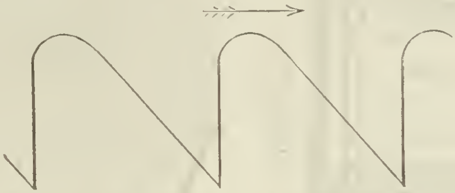


Fig. 25. Drag Saw Teeth for Firewood.

For farmers' use drag saws are 4½ to 6 feet long, and tapered from 7 to 5 inches; stroke 40 to 60 per minute. In shingle mills they are much heavier, and run 80 to 120 strokes per minute; are 5½ to 8 feet long; sometimes tapering from 10 to 6 inches and sometimes 10 to 12 inches wide throughout.

Drag saws for firewood are generally made with a tooth such as shown in Fig. 25. When the cutting is done on the pull stroke, thinner blades may be used than with double cutting saws; but the latter will saw smoother, and are used in drag sawing logs for shingle bolts, because it is desirable to make the edges of shingles as smooth as possible.

Coquillion's Grisoumetre.—This apparatus is designed to show, at all times, whether there is enough fire-damp in a mining shaft or gallery to be dangerous. The report of the engineer's of the Aniche Mining Company states that an experiment of five minutes' duration revealed the presence of one-quarter of one per cent. of the deleterious gas. This remarkable delicacy has attracted the general attention of mining engineers in France and Belgium, Whatever improvements may be made hereafter in the apparatus, the inventor will always be entitled to great credit for his fearless exposure to the dangers of explosion while pursuing his investigations.—*Les Mondes.* C.

CORBIN AND GOODRICH
AND
THE BOILERS OF MR. CAMPBELL.

By W. Barnet Le Van.

The December Journal of the Franklin Institute contains an article on "Steam Boiler Explosions," in which I am referred to as the expert employed by Mr. George Campbell to design boilers for his mill at 21st and Washington avenue.

On page 399 of said Journal, commencing at 14th line from the top, the following will be found:

"We are very glad that he (Mr. Nystrom) has seen fit to refer to his report on the boilers built for Mr. George Campbell, as events have transpired subsequent to that report which show, beyond question, what the result of his inspection led to. The boilers were built by the Baldwin Locomotive Works, according to specifications furnished by Mr. W. Barnet Le Van, who was employed by Mr. Campbell as an expert for that purpose. The boilers were of the type known as horizontal tubular boilers, the lower cylinders being 54 inches in diameter and containing 50 4-inch tubes; the upper cylinders were 30 inches in diameter, and they were connected by two 12-inch necks. When the boilers were finished and our inspectors were called in, preparatory to insurance, it was found that the upper row of tubes in the lower boiler came within 8½ inches of the top. *Allowing for 4 inches of water above the tubes, the surface for disengaging steam was so small that it was apparent to us that nothing could keep the water at an even height, or prevent it from being driven altogether out of the lower boiler at times. We immediately declined to insure the boilers, and so informed Mr. Campbell,* who, naturally desiring further light upon the subject, referred the matter to various experts, and among those so consulted was Mr. Nystrom."

On page 400, fifth line from bottom, and on page 401, is the following:

"Now, what was the result? Encouraged by such teaching as the above, Mr. Campbell was induced to put in two of the boilers at first constructed under Mr. Le Van's specifications, and when they were fired up the effect was precisely that foretold by our inspector, *and the water, instead of showing a variation of an inch, as stated by Mr. N., a 12-inch glass gauge was not long enough to keep track of it, and no amount of persuasion could keep the water in the lower boiler when fired as originally intended. After several ineffectual attempts to remedy the fatal defects, the boilers were placed in the hands of the Hartford Boiler Insurance Company for such reconstruction as we thought necessary to make them work satisfactorily.*

"*At our direction the Le Van boilers were entirely overhauled*, changing their length to 18 feet instead of 14, and putting in 28 4½-inch tubes, leaving a clear space of 18 inches from top of tubes to shell of boiler. We also enlarged the necks, to save putting a man-hole on the top of the lower boiler. It was at this point that *we stipulated what thickness of material should be used in the necks.*"

Portions of the extracts are printed in italics for the purpose of easy reference.

The following statement sets forth the exact facts in the above matter:

In the fall of 1878 Mr. George Campbell invited me to furnish him with a working drawing of boilers for his mill at 21st and Washington avenue, in this city. The space to receive them at that time was 17 feet in width by 18 feet in length, and the power required was 300 horse power. On plotting, I found that for three boilers the largest diameter that could be employed in the space was 54 inches, and the greatest length 14 feet, and to develop 100 horses through *his* Corliss engine each boiler would require 50 flues four inches in diameter.

Plans were submitted by others in addition to those of myself.

On or about the first of May, 1879, Mr. Campbell informed me he had examined all the plans of boilers submitted, and that Mr. Pike, the inspector of the Hartford Boiler Insurance Company, had examined them, and he had concluded to adopt the plan of boiler furnished by me, and Mr. Campbell requested me to draw up specifications so that he might have estimates for building them, subject to the inspection of Mr. Pike.

Several bids were received from prominent boiler makers, and after accepting my proposition the boilers were ordered to be built by the Baldwin Locomotive Works.

They immediately proceeded to build them, and during their construction the Hartford Boiler Insurance Company were notified, so that their Mr. Pike might inspect them in detail. Mr. Pike met me at the Baldwin Locomotive Works several times during their construction, and when the first boiler was ready to receive the water test, Mr. Pike was again notified, and was present, as he also was when the first and second boilers were under pressure of both water and steam at Baldwin Locomotive Works.

No objection was made by him up to this time as to material, workmanship or design.

Before the third boiler was ready for a water test, the Wilt & Son's boiler explosion occurred, and the writer was subpœnaed as an expert by the coroner of this city to testify in reference to the cause of this explosion. The boiler at Wilt & Son's mill was insured by the Hartford Boiler Insurance Company, and was under Mr. Pike's inspection.

In July, 1879, the third boiler was finished, and Mr. Pike was again notified to be present, *and at this trial he for the first time informed me that he could not insure these boilers* for (in substance) the following reasons:

1st. That they did not have sufficient outlet from the flue shell of the boiler to the steam drum; that two 12-inch necks were not of sufficient capacity for the proper discharge of the steam generated; that these necks should have been *four* in number, each 12 inch diameter, in place of two as now constructed.

2d. That there was not sufficient surface of water for disengaging of the steam, and that the *water would be driven out of the lower boiler into the steam drum,* and that therefore *they would not be safe to use as at present constructed,* and that before he would consent to *insure them he would insist on the two top rows of flues being taken out.*

This was a complete surprise to me, as no objections to the mode of construction had been made by him or any other person prior to this. I at once consulted with several prominent boiler engineers, none of whom agreed in opinion with Mr. Pike.

After a few days I again met Mr. Pike, and then he informed me he would withdraw his objection in regard to the number of necks if I would increase their diameter to 16 inches in place of 12 inches as now constructed, but he still insisted on the removal of the two top rows of flues as before stated; that he had written to the home office in regard to these boilers, and that Mr. Allen, the President, in reply had left the matter entirely in his discretion to do as he thought fit, and therefore that the above was his ultimatum, as his reputation was at stake, and that the Company *would rather lose the insurance than take a risk on the boilers as then constructed.*

Mr. Campbell, after hearing the opinion of other engineers coinciding with mine, said he was satisfied, but would like to have them examined on his own account, in which wish I concurred.

He also requested me to furnish him with the names of a number of engineers who were experts in this matter, from which he could select one or two to give him a written opinion, which I did.

From the names so furnished he selected Messrs. Edward Longstreth and John W. Nystrom, and on their written report he ordered the two boilers now finished to be erected.

After being erected the Hartford Boiler Insurance Company's inspector, Mr. Pike, refused to pass them. Mr. John Overn, the City's Boiler Inspector, was then notified and the above facts were related to him and he at once inspected them in person, and authorized Mr. Campbell to have them put in operation.

When first fired up they foamed badly on account of the grease and oil left on their surfaces in the course of manufacture. Foaming occurs more or less in all new boilers.

During their first steaming and from the necessity of keeping the mill in full operation, consequent upon extensive alterations, these boilers were forced over their capacity, as they had at times to drive one-half the work of the mill and the shafting also, the power required to do which was never less than 225 horse-power, and at times 250; whilst the boilers were designed for only 100 horse-power each. This will account for the variation of the water-level referred to.

When the boilers first ordered, were nearly completed Mr. Campbell enlarged the boiler room so that it could then accommodate longer boilers than 14 feet; he also increased the number ordered, first to four, then to five, in place of three as at first contemplated.

During Mr. Campbell's absence from the city the Hartford Boiler Insurance Company induced the Superintendent of the mill to change the other three boilers (one of which was finished but not erected) to 18 feet in length instead of 14, and reduce the number of flues to 28 four and one-half inch flues, by which alteration the power of the boilers was reduced 20 per cent., and also to increase the diameter of the necks to 16 inches diameter in place of 12 inches, thereby decreasing the strength of the boilers about 25 per cent.

When the Superintendent directed a change to be made in the third and fourth boilers, which were completed but not erected in brick work, I protested, but without avail. Directions having been given to make the change, I then desired that the necks should be made of metal one-half inch thick, in order to compensate for the decrease of strength caused by cutting holes 18 inches in diameter for the accommodating of the larger necks ordered to be put in. This was consented to by Mr. Pike and the Superintendent of the mill at the time the order was given to the Baldwin Locomotive Works. The next morning Mr. Pike called at Baldwin's and *changed* the order from *one-half inch in thickness for the necks to three-eighths in thickness*, stating that if *half inch* in thickness was used he would not insure the boilers.

This alteration of the order I was not aware of until several days had elapsed; the plates had been ordered by telegraph to be made at the Otis Steel Works, Cleveland, Ohio, and were probably completed.

The assertions made by Corbin and Goodrich, Agents of Hartford Boiler Insurance Company, in their communication in the December number of the JOURNAL OF THE FRANKLIN INSTITUTE, herein quoted from pages 399, 400 and 401, are not true, and are calculated to injure the writer by the false impressions they tend to produce, making it proper for me to set forth the facts as they actually occurred.

The two boilers first built were constructed *in exact accordance with my designs, and without any alterations;* they were set in brick work in the boiler room in the mill, and then fired up and put into service.

These boilers are still in service, and have been since September 5th, 1879, *unchanged in construction, and giving entire satisfaction.*

Moreover, I have been informed by Mr. Campbell that *they have been recently insured* by the Hartford Boiler Insurance Company, notwithstanding the statements that have been published by that company in this journal.

Furthermore, I have been informed by the engineer of Mr. Campbell, in the presence of Mr. John Overn (Chief Boiler Inspector of this City) and of Mr. Edward Longstreth, of the Baldwin Locomotive Works, that he had no trouble whatever in maintaining a steady water-level in these boilers, and that when the engine was stopped suddenly the water never fell in the glass water gauge over *one inch.*

To-day, December 24th, 1879, I met Mr. Pike at Mr. Campbell's mill, and he corroborated Mr. Campbell's statement in regard to insuring the two first boilers erected by me, and which they had at first refused to insure.

In conclusion, I desire to call attention to the quotations from the December JOURNAL, which I have italicized, and to show the inconsistency of the statements of the agents of the Hartford Boiler Insurance Company, regarding the boilers in question, with the action of the company in insuring the same.

THE WIRE BOOK SEWING MACHINE.

By H. BILGRAM, M.E.

Read before the Franklin Institute at its meeting, October 15th, 1879.

The most important step forward that has lately been made in book binding is undoubtedly the substitution of wire for thread. A machine for sewing books with wire was recently exhibited at a meeting of the Franklin Institute, where several books were sewed before the audience.

The principle of this machine consists in producing a number of U-shaped wire staples, which are driven *from the inside* of each section of the book through the back and through one wide or several narrow bands of a strong linen or cotton fabric, whereupon the ends projecting through the back are clinched over, and thus a firm connection between the sheets of the section themselves and the band or bands covering the back of the book is produced. The machine fastens a section at each revolution of the main shaft, and can be run at 40 to 43 revolutions per minute. The book sections are fed by the operator, partly opened, upon a table which, by an oscillating motion, brings the sheet in position to be sewed. By an adjustable downward feed of the table on which the book is sewed, the sections can be sewed tight or loose, to suit the degree of "backing" in the subsequent forwarding of the book.

The principal merits of this mode of binding books are strength, durability and flexibility, besides the saving of labor, as an operator can turn out as much work on one of these machines as from five to eight operators can do by hand. Greater strength is given by the several sheets of each section being clamped firmly between the back and the clinched legs of the wire staple while the thread in thread-sewed books holds the centre sheet only by the edges of the cuts through which the thread passes. If the inner sheet of any section of a thread-bound book be torn out by force, the thread cuts its way through the fold of the sheet; while in a wire-sewed book the sheet will tear in a double line, leaving a small strip of paper underneath the wire staple. This simple test proves at once the superior strength of a wire-sewed book.

The firmness of a wire-sewed book is not so much dependent on the gluing of the back as is the case with a thread-bound book. The inner sheet of any thread-bound book is held in position by the glue in the several saw-cuts; for if this connection is carefully severed without injuring the thread connection, the sheet can be moved up and down as much as the thirty-second of an inch, while nothing short of actual tearing of the paper can make the corresponding sheet of a wire-sewed book move through the same distance.

Rusting of the iron wire is effectually guarded against by tinning it.

Increased flexibility is insured by the diminished thickness of the flexible back of the book. In the old way of binding, the flexible connection of the several sections of the book is represented by two or more comparatively thick strands laid in the saw-cuts on the back of the book, and held there by the thread passing round them; while on the wire-sewed books the corresponding connection extends over the greater part of the back, and is not only much thinner and more flexible, but also much stronger. The book opens very freely indeed.

In binding the first books sewed with wire, some difficulty was experienced in the wires thickening the back of the book so much that in pressing it for the purpose of cutting, the paper was crushed by the wire just where it should have been strongest. This defect has been overcome by inserting the staples in a zigzag line, so that there appear two or three times as many rows of staples on the back as there are staples in each section.

In Europe these machines have been introduced with a remarkable rapidity, there being now about 150 of them in successful operation in England, Germany, France, Belgium, etc. Both the United States and the English Government binderies have adopted them, and thereby considerably reduced the cost of binding, besides producing superior work. Especially for the manufacture of blank books is this mode of binding superior, as is shown by the fact that in Germany hand-sewed books are sold at a discount in order to compete with the wire-sewed work.

ON THE METHOD OF MILK SHIPMENT IN GLASS JARS.

By J. CHESTON MORRIS, M. D.

Read before the Franklin Institute at its meeting Dec. 17th, 1879.

No more important subject can engage the attention of a community than that of the purity and abundance of its food supply, and no one article of food is of more importance to every class in the community than that to which I wish to direct your thoughts for a few moments this evening, constituting in some form an essential ingredient in the food of almost every one, from the cradle to the grave. Even among savages its value is appreciated; and as men rise in civilization we find them more and more dependent upon it and using it in more various methods. The natural food of all young mammalia, it still constitutes the best and most available form of nutriment in health and disease. How important, then, that it should be as fresh, pure, and rich as possible. Here, however, comes the difficulty. It is perishable, quickly prone to change and very susceptible of becoming tainted by contact with impure substances—nay, even of becoming the vehicle through which organic poisons, such as that which produces typhoid fever, may be disseminated according to some authorities. And the difficulty increases with the size of a community, which involves increased distance from the source of production and renders it necessary that it should pass through one or more hands between the producer and the consumer. In the sharp competition of trade this renders it liable to adulteration as well as to the certain deterioration which ensues upon the loss of time in transit. No wonder then that the article which in town we know as "milk" is so different from that we find in a country spring-house. I do not mean that good milk is not, very often, delivered by the milkmen in Philadelphia; on the contrary, I believe that our milk supply here will contrast favorably with that of most other large cities. But there is room for improvement—in many cases a great deal of room—and it is much to be desired that any means to affect this should be made known as widely as possible. Having been engaged practically and, I may add, successfully in an effort toward this for more than a year, I wish to lay my method before you, and thus contribute my mite for the public good.

The cows at my farm, near Westchester, are all pure Devons, and are fed on good nutritious food—hay, bran, corn meal, potatoes, beets, or ruta-bagas—and are well housed, so as to maintain them in good health. Their udders are carefully washed before they are milked. The milk, as soon as drawn, is strained into a 40 quart can, in the centre of which is suspended a 10 quart can containing a freezing mixture of ice and salt, so as to reduce the temperature as rapidly as possible to 50° F. When the thermometer shows this to have been accomplished (which will require 15 to 20 minutes) the milk is drawn off by a faucet into quart jars (I use the Cohansey fruit jar, as being convenient and meeting all requirements), and each jar is closed and sealed with a label bearing the name and address of the producer, date of shipment, and quality of the milk. This label (a slip of paper pasted or gummed) cannot be removed or tampered with in transit without destroying it. Twenty of these jars are packed in a box, and are ready for shipment and delivery to customers. In warm weather one jar in the middle is filled with ice. The milk may be kept in them until required for use. The empty jars are to be rinsed and returned when fresh ones are delivered. The advantages of this method are as follows:

1. The milk must be clean, as any dirt would show at the bottom of the jar.

2. It is free from contamination by foul air, etc., in transit. This is a very important advantage, as any one can appreciate who has happened to enter an ordinary milk car and noticed the foul putrescent odor which results from the slopping of milk over the car floor, when it soaks in and undergoes decomposition.

3. Each quart of milk contains its own share—no more, no less—of cream. When 40 quarts are sent, as is usually the case, in a "churn," the cream soon rises to the upper part, and the abstraction of more or less cream from the milk is easy. To obviate this the milkman may frequently be seen stirring up the contents of his can, but it may readily be surmised that favorite customers may receive some share of cream that properly belongs to others less fortunate.

4. If the jars have been properly filled no "churning" is possible. In the ordinary method more or less churning is apt to take place.

5. The consumer can be sure that he gets the real article furnished by the producer.

6. It is the interest of the producer to send the best article he pos-

sibly can, as the price he will receive depends upon it, and consumers will not be slow to show their appreciation of his merit or demerit. In the ordinary mode this is not the case. Milk is milk, and the man who really and honestly tries to send the *whole* produce of his herd finds he receives no more for it than his dishonest neighbor who removes part of the cream, or adds a little water.

The average yield of a good cow may be estimated at 2400 quarts per annum, or between 6½ and 7 quarts daily. At the usual prices of corn, hay, etc., the cost of keeping would be nearly 30 cents daily. The cost of production, therefore, is not less than 4½ to 5 cents per quart. It will readily be seen that when the risks and cost of transportation are considered the farmer does not make a large profit, even if he gets his fair proportion of the 8 or 10 cents per quart, which are the ruling prices—the former in summer, the latter in winter. But even this he does not get, as the price of milk at the railroad depots is 2½ cents in summer and 4 cents in winter. Of course somebody suffers for this.

To return to the quality of milk, and especially to the variation which occurs in different breeds.

The *Durham*, or short-horn cow, yields a large quantity of milk, rich in casein but poor in butter and sugar. The ordinary or "common" cow is largely "grade Durham," and may be classed under the same head. Rather richer in butter and less watery is the yield of the *Holstein* or Dutch cow, a variety of the short-horn class. Next comes the *Ayrshires*, a very useful class.

The *Jerseys*, or Alderneys, yield a comparatively small quantity of milk, very rich in butter but poor in cheese and sugar; hence when the cream is removed there is only a very poor skim milk left. These animals are not fit for dairy cows for milk purposes. But "grade" Jerseys yield abundantly a good article.

The *Devon* cow stands intermediate between the Durham and Jersey as to amount of yield and percentage of butter, but yields a milk richer in sugar than any other, and hence better adapted for general use, more nutritive and palatable.

As to the sort of glass-jar required, it should have a large opening, so as to be cleansed readily; it should be capable of being completely filled, and should be easily closed and opened. Any jar fulfilling these conditions may be used. After I had used the Cohansey for six months I saw Mr. Lester's jar, which is good but cumbrous. That used by Mr. F. Ratchford Starr of New York, as well as the bottles employed by M. D'Arcy in Paris, seem to me not so convenient, on account of the narrowness of the mouth; cream could not be taken separately from them so readily.

The importance of this branch of trade may be estimated when it is known that the milk supply of Philadelphia is nearly 150,000 quarts daily, costing the consumers, at eight cents per quart, nearly $12,000, or annually about $4,376,000. And yet the quantity daily consumed by each individual, supposing the population of Philadelphia to be 850,000, is less than one-third of a pint for each man, woman and child. This is rather more than the average of England, though less than half that of Wales, and not one-third of that of Scotland or Ireland.

The nutritive value of milk is hardly sufficiently appreciated by us. According to the best and most recent analyses, good milk contains, in each quart:

Butter,	543·3	grains,	or	nearly	1¼	oz.	avoirdupois.
Casein,	1026·3	"	"	more than	2¼	"	"
Milk-sugar,	452·8	"	"	" "	1	"	"
Salts (phosphates, etc.),	90·6	"	'	nearly	⅓	"	"

Two quarts, therefore, of milk, with 12 oz. of bread, contain sufficient nutriment for a laboring man daily—more than the French cavalry ration. No cheaper food of equal nutritive value and easy assimilation can be found.

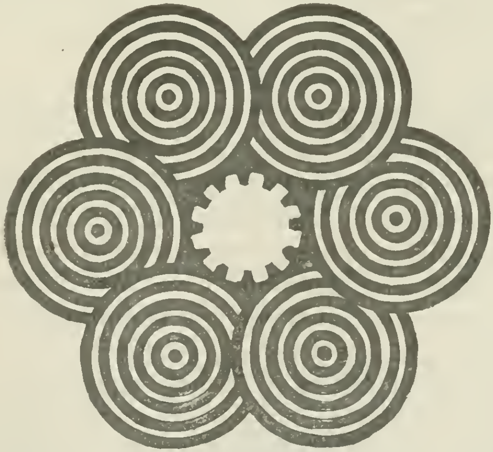
The Satellites of Mars.—On the 10th of October Prof. Hall found Deimos, the outer satellite, almost precisely in the calculated position. The place of Phobus was not predicted so accurately, because its proximity to Mars made observations more difficult, and some of the auxiliary estimates were calculated for the orbital plane of Deimos. But these difficulties have exerted only a very slight influence on the results. Both positions are within the limits of probable error, which were announced by the discoveries in 1877. The 2443 intervening revolutions of Phobus require a diminution of only 1·074 sec. in the predicted time, showing an error of less than $\frac{1}{275}$ of one per cent.! A very careful and exact reduction of observations will be necessary in order to determine whether any correction is needed in the elements of Deimos.—*Comptes Rendus.* C.

A NEW ILLUSTRATION OF "PERSISTENCE OF VISION."

By Prof. Silvanus P. Thompson.

A friend has called my attention to an article in the November number of your Journal, by Professor T. W. Tobin, bearing the above heading, and treating of some curious optical illusions discovered by me about three years ago. A quotation is given by Professor Tobin, I know not from what source, which certainly was not written by me, and concerning which I beg to make the following remark:

I have always maintained that the illusion was due in part to the "persistence of vision." For eighteen months the published sets of cards have been before the public, and the printed description which accompanies each packet runs as follows: "This new and interesting Optical Illusion depends upon the well-known scientific principle of the Persistence of Vision, namely, that an object placed only for an instant before the eye is seen for an appreciable time after its removal, its image remaining about the eighth of a second on the retina of the eye. If the card be held between the finger and thumb, and moved rapidly in circles with a slight motion of the wrist, the circles will appear to rotate on the card."



At the same time I have always maintained that persistence of visual impressions failed to account for several of the phenomena accompanying the illusion. In the first place, I find that there is a particular distance from the eye which suits best a set of circles of a particular size. Very numerous and narrow circles exhibit the "rotation" excellently when held at a few inches from the eye, but at three feet distance quite fail; whereas a set of circles in which the alternate rings of black and white are three inches in width from ring to ring do not show the effect at all a foot away, but show it capitally to an audience of a hundred persons. Apparently, to obtain the best result, the width of ring must be proportional to the distance from which it is to be viewed.

Again, if some of the "circles" are lying on the table in view, while a set are being "rotated" by hand, those lying on the table will seem to rotate, though the eye is looking at the moving "circles." This observation, like the preceding, is absolutely inexplicable without recourse to some further hypothesis than that of the *persistence of visual impressions*. Moreover, the illusions succeed best if the eye be directed not at the circles themselves but at some point near. For this reason I have found it best to have *two* sets of circles printed side by side on the card; that set rotating most effectively at which the eye is *not* directed.

As to Professor Tobins's elegant demonstration that the successive displacements of a circle around its centre are optically equivalent to the eccentric rotation of the circle itself about some central point, it is deductively perfect; only it falls short where the theory of persistence of vision in general falls short, and cannot afford the complete explanation of the other phenomena I have described.

I may perhaps mention, in conclusion, that M. Duboscq, of Paris, has recently constructed for me a little piece of apparatus which enables me to project the circles upon the screen on a large enough scale for an audience of a thousand persons to witness the illusion at one time.

University College, Bristol, England, Dec. 12, 1879.

Bessemer Steel in Europe and America.—The production of Bessemer steel, since 1870, has advanced from 40,000 tons to 550,000 tons in the United States, and from 250,000 to 750,000 tons in England. Germany and France each produce about 250,000 tons, and the rest of Europe about 200,000 tons.—*Rev. de Engenh.* C.

VELOCITY OF LIGHT.

By Pliny Earle Chase, LL.D.

The late experiments of Michelson, and those upon which Newcomb is now engaged, may lend interest to approximations to the velocity of light by the nebular hypothesis.

On the 24th inst., I found the first of the values which I give, in connection with other recent estimates, in the following comparative table. The only elements required in the calculation are, the force of gravity at the equator, the diameter of the earth, and the lengths of the terrestrial day and year.

I have found, to-day, the second value, which I am inclined to regard as still more accurate.

Light requires 497·827 seconds to come from the sun to the earth, a distance of 214·54 solar radii. If planetary revolution were possible at sun's surface, the velocity $\sqrt{gr}$ would be ·00062563 r per second, or $\frac{1}{688{\cdot}84}$ as great as the velocity of light. The solar *modulus* of light, M, is therefore 474,500 r. According to Stockwell, the centre of the dense belt of planets, or the primitive centre of greatest condensation, C, is at 1·016878 earth's mean radius vector, or at 218·16 r. From the necessary action and reaction between the nucleal centre and the principal centre of condensation I deduce the equation,

$$\left(M \times C \right)^{\frac{1}{2}} = \frac{1 \text{ yr.}}{1 \text{ dy.}} \times \frac{g^{\circ}}{g'}$$

From this equation we readily find 27·78 for the quotient of solar by terrestrial equatorial gravity, $\frac{g^{\circ}}{g'}$, and 185,852 miles, or 299,090 kilometres, for the velocity of light per second.

	Velocity of Light.		Neptune, sec. perihelion.
Foucault,	298,000 km.	Leverrier,	29·602
Cornu,	300,000 "	Stockwell,	29·598
Perry and Ayrton,	298,000 "	Newcomb,	29·619
Michelson,	299,820 "	Chase,	29·608
Chase, 1,	298,030 "		
" 2,	299,090 "		

In the estimates of Neptune's secular perihelion, I have adopted Stockwell's value for the greatest secular eccentricity, ·0145.

Haverford College, *Dec.* 29*th*, 1879.

IRON BRIDGES.

When the public was startled by the fall of the St. Charles bridge, it derived much consolation from the fact that only a freight train was engulfed by the catastrophe. Scarcely has the public ceased to congratulate itself over the small loss of life attending the failure of that splendid structure, when the cable flashes from England the intelligence that another great railroad bridge has gone down, and furnished a fearful example of what might have been, had the St. Charles bridge succumbed to a passenger train.

The longest railroad bridge in the world, over running water, is the bridge over the river Tay, in Scotland. It is 10,612 feet in length, or 52 feet more than two miles. It consists of 85 spans, of varying extent, eleven of them having a length of 245 feet each. It is an iron truss, and at its opening, in May, 1868, it was subjected to the most rigid tests, and was pronounced a great triumph of engineering skill. English engineers have envied their American brethren because the latter have, of late years, so greatly surpassed them in the construction of iron bridges. As an English engineer put it, "Nature has especially favored the Americans in giving them great rivers to cross." When, therefore, this magnificent bridge across the Firth of Tay was pronounced finished, and was opened with imposing ceremonies, English engineers congratulated themselves that their island had at least one structure which would rank with the most noted American examples. But this pride of English engineering has succumbed in the midst of a hurricane, and an entire train containing more than 200 passengers plunged into the water beneath it, and not a single reservoir is left to furnish materials for a plausible theory of the accident. The eleven large spans are reported to have disappeared, leaving only the naked iron piers on which they had rested. It is the most appalling railroad accident that has ever occurred. Three hundred travelers left their homes that day forever, and were never more unsuspicious of danger than at the moment before they plunged into eternity. The suddenness of their fate and the horrid completeness of their taking off are too terrible to dwell upon.

Will the cause of this fearful disaster ever be known? is a question now of very great importance. Are the failures of such bridges as the St. Charles and Tay the result of inherent defects of construction, or must they be ascribed to accidental causes, which can be surmised but not demonstrated? Although the bridge builder's art is very old, he is now exercising it under new conditions. The advent of the locomotive calls for the exercise of his powers on a scale never before known. The old methods of travel admitted of such devices as fords and ferries in the passage of streams, but the iron horse will have none of them. Whenever he approaches a river he imperiously demands a bridge, and he does not leave the engineer much choice of crossings. Wherever traffic seems to point out a pathway, there he must go, and no matter what difficulties lie in the way, they must be surmounted. The largest rivers are not allowed to bar his progress, and giant streams, which, but for him, would have been ferried over for ages, must now be spanned by structures superior in strength to any heretofore known. Hence, although the bridge builder's art has the perfection which comes of long practice, the locomotive is severely taxing his resources.

Bridge-building, like civilized man himself, has had its three ages. First, came the age of wood, then followed the age of stone, and lastly the present wonderful iron age. The use of iron in bridge construction has produced a boldness of conception in the present generation of engineers which casts the performances of their predecessors entirely in the shade. A half century ago such spans as the fallen ones of the St. Charles and Tay bridges, for such loads as they were calculated to support, were impossible. Now they are far from being of the first magnitude. There are ten truss bridges across the Mississippi above St. Louis, which are not regarded as very wonderful structures, and yet seven of them have spans as long as those of the Tay bridge. The bridges at Winona, LaCrosse, Dubuque, Keokuk and Hannibal have spans of 240, that at Rock Island of 250, and that at Louisiana of 256 feet. The span which gave way at St. Charles was 320 feet in length, yet the same bridge has two spans 406 feet long. Over the same river is a truss bridge, at Leavenworth, with three spans 340 feet, and another at Glascow with five of 315 feet. Across the Ohio there is a truss bridge, at Steubenville, with a span of 320 feet, one at Parkersburg of 350, one at Cincinnati with a span of 515 feet, the longest truss yet built, and one at Louisville with a span of 400 feet. The truss bridge over the Kentucky river, on the Cincinnati and Southern Railroad, has three spans 375 feet in length resting on iron piers 175 feet high. The bridge over the Hudson, at Poughkeepsie, has five spans of 500 feet, with piers 135 feet above high water. In Europe there is a truss bridge over the Vistula, at Graudenz, with 12 spans of 300 feet. The truss bridge of Lessart, in France, has a span of 314 feet, and was pushed across from one abutment to the other after being put together. The bridge over the Rhine, at Wesel, has four spans of 313 feet. The Kulenburg bridge, in Holland, which was the monarch truss before the construction of the Cincinnati bridge, has a span of 492 feet. From these examples it would seem that the St. Charles and Tay bridges, instead of being risky engineering ventures, are entirely within the domain of experience. But, nevertheless, the fact remains that, notwithstanding the boldness with which the engineers of the present day meet the exactions of the locomotive, they are comparatively novices in the use of iron. The first iron bridges were of cast iron, and soon proved to be too lightly proportioned. The first suspension bridges were similarly defective. Does it remain to be proved that the wrought iron work of the past twenty years betrays too great a confidence in the material? Were the St. Charles and Tay disasters unaccountable accidents, or were they fair tests of current engineering theories? These are questions which engineers would do well to discuss.—*St. Louis Globe Democrat.*

Pictet's Calorific Syntheses.—Pictet modifies Mossotti's hypothesis, by supposing that atoms attract each other as well as attracting ether. He regards the gaseous atom as simple, the liquid molecule as composed of at least two gaseous atoms, and the solid molecule as containing at least two liquid molecules. Starting from the amplitude of calorific oscillation, he explains, by simple mechanical laws, the law of Mariotte and Gay Lussac, the anomalies with their limits and the conditions of passage from the gaseous to the liquid state, the mobility of liquids, their feeble compressibility, their diffusion and volatilization; the rigidity, elasticity, hardness, axes of crystallization, allotropism and amorphism of solids; the absolute zero temperature, thermic equilibrium and specific heat of bodies; the law of Dulong and Petit; fusion, evaporation, latent heat, density, vapor-tension, and nearly all the phenomena of thermo-chemistry. He thinks it probable that the dimensions of atoms and molecules may be deduced from his experiments.—*Bull. de la Soc. Vaud.* C.

ELECTRIC LIGHTING AT THE BRITISH MUSEUM.

When the electric light was first pronounced to be a practical success, the authorities of the British Museum resolved to give the frequenters of the reading-room the advantage of that method of illumination during the hours of darkness and fog which so frequently prevail at certain seasons of the year. Accordingly last autumn, as our readers will remember, the reading-room was lighted by the Jablochkoff system, which, so far as it went, is stated to have given every satisfaction. Being desirous of giving each practical system a fair trial, the authorities of the Museum have this year adopted experimentally the Siemens system of electric lighting, which was exhibited last evening for the first time to a select party of scientific gentlemen and others interested in the question.

The proposals for lighting up the reading-room by this system were originally submitted by Mr. J. J. Calder and Mr. J. A. Barrett, and the arrangements were finally carried out under the superintendence of Mr. Barrett, who is the electrician for the Museum. Eleven lights in all have been fitted up, and of these four are placed in the reading-room, four in other parts of the building, and three outside of it. The four in the reading-room are placed, one in the centre and three equidistantly around it. They are supplied with continuous currents, each from its own Siemens dynamo-electric machine. Of the lights in other parts of the Museum, two are placed in the entrance-hall, one in the reading-room corridor and one in the Greek gallery. In the courtyard in front of the building are two more lights, while another is placed in the rear, near to the engine and machine house. These seven lights are supplied from one Siemens machine, producing an alternating, or divided current. It will thus be seen that two different systems of electric lighting are employed, both, however, being on the Siemens principle—the four lights in the reading-room being produced by continuous currents, and calculated to be each equal to 4000 candles, the seven other lights, which are estimated at 400 candles each, being produced by an alternating current, and being connected in one circuit about 1200 yards in length.

The lamps in the reading-room are governed by regulators, which are the invention of Messrs. Siemens and Halske, of Berlin. These regulators are of very simple construction, and consequently can be managed without any special electrical knowledge. The carbons are 19 inches in length, and their rate of consumption is about three inches per hour, so that the light can be maintained for six hours without touching the regulators. The lights produced by the alternating current are fitted with a different kind of regulator. These regulators are actuated by two solenoids on a differential principle. One solenoid forms part of the main circuit and tends to separate the carbons, while the other forms a shunt round the carbons and tends to bring them together. The position of the carbons depends, therefore, not on the strength of the current, but on the relative amount of electricity passing through each solenoid. By selecting suitable resistances for each coil an arc of a given resistance will always be maintained, independently of the strength of the current. This obviates the necessity for regulating the lamps after they have left the hands of the makers. The arrangement of these regulators is such that should one light in the circuit become extinguished, the others will not be in any way affected. The carbons in these lamps burn for about five hours and can be replaced in about a minute. The lights in the reading-room are suspended from the roof, and are enclosed in octagonal lanterns, filled in with ground glass, and having circular reflectors placed over them. The other lights in the building and that at the engine-house are also suspended, while the two in the fore court are placed on standards. They are all enclosed in ground glass globes.

The machines for producing the currents are six in number, and are placed in a small house to the rear of the Museum. Of these, four are the continuous current machines for supplying the four lights in the reading-room; one is the alternate current machine for supplying the other lights, while the sixth is used as an exciter for all the rest. The leading wires from the machines to the lights in the reading-room are carried over the roof of the building to the lantern on the top of the dome, a distance of about 200 yards. The wires for the other lights are laid partly in the basement of the Museum and partly underground. The motive power for driving the machines is supplied by two 8-horse semi-fixed engines by Messrs. Wallis & Stevens, of Basingstoke. These engines embody several special features, which render them particularly applicable for driving machinery for generating electricity for lighting purposes, foremost among which is perfect regularity of speed, which is maintained by a special kind of governor. The maintenance of an uniform speed is of the first importance in electric lighting, inasmuch as any slight variation in the engine causes irregularity in the light and vitiates the results. The power is transmitted to the electric machines through belts and shafting, and the whole arrangement during our visit worked steadily and well. The revolutions of the engine were 125 per minute, and the steam pressure about 60 pounds per square inch. On the whole, the experiment was perfectly successful, an excellent and agreeable light being produced and maintained. A slight unsteadiness was apparent at times in some of the lamps, but this was stated to be due to defective carbons. This reason is so frequently assigned for aberrations of various electric lighting systems that it would be as well if carbon manufacturers would set to work to produce carbons of perfectly uniform quality, and thus get rid of this drawback to electric lighting.—*London Times.*

Superficial Viscosity of Liquids.—In the course of his experiments upon the equilibrium of liquid masses without weight, Plateau found that some liquids showed a special resistance at their surfaces while others were more viscous in the interior. The difference may be studied in the following manner. Place a magnetic needle on a pivot in a cylindrical glass vessel; pour in the liquid until it reaches the lower surface of the needle; turn the needle 90° from the magnetic meridian, then release it and notice the time occupied in traversing a specific angle. In his experiments the angle was 85°. Then add more liquid, so as to completely submerge the needle to a depth of about 2 centimetres (·79 in.), turn the needle 90° and note the angular time as before. For distilled water, the time in the first experiment was nearly twice as great as in the second, though in the former case the friction against the water was only on one surface, while in the latter it was on both surfaces of the needle. In spirits of turpentine or in alcohol, the time on the surface was less than half as great as in the interior. A solution of albumen and a solution of saponine had remarkable superficial viscosity. On the surface of the former, the needle stopped after slowly turning an angle of 35°; on the surface of the latter it did not even begin to move. Luvini and Maranzoni have attempted to controvert Plateau's views, but he has shown in what respects their experiments were defective.—*Bull. de l'Acad. de Belg.* C.

Irrigation by the Tagus.—A proposal has been laid before the Portuguese Government to build a dam across the river Tagus, about 20 km. (12·43 miles) above Abrantas, in order to raise the level sufficiently to irrigate about 400,000 trueus (988,657 acres) of the adjoining lands. The expense would be very small in comparison with the increased value of the land, which is estimated at 600,000,000 francs ($120,000,000), or nearly one-third of the Portuguese national debt. —*Chron. Industr.* C.

African Railway.—Duponchel's projected railway for connecting Algeria with Soudan continues to excite great interest in France. A commission of 65 members has been appointed, and divided into four sub-commissions. The first, under the presidency of de Lesseps, is to collect statistical and economical information; the second, under Duponchel, is devoted to technical studies and the determination of routes; the third is to have charge of the explorations, and the fourth will consider international questions, especially with reference to the Moors, the Tripolitans and the Toncuezs. Many of the senators and deputies, who are members of the commission, have visited Algeria in order to understand the different projects which are to be brought before them.—*Les Mondes.* C.

Precautions in Comparing Weights.—Deville and Mascart, in explaining the construction of the international geodetic standard, give an interesting account of some of the necessary precautions: During the long series of operations upon which a comparison of two weights is based, a balance should never be opened. Its cage, composed of two envelopes of glass, bordered with cloth, should be guarded from the external air, which would change the hygrometric state of the interior, and which would introduce dust. The particles of dust notch the knife-edges, and change the velvet linings of the weight-boxes into a material comparable to emery-paper. Air may be forced into the interior, at the rate of 4 or 5 litres (4·227 or 5·283 qts.) per hour, being first deprived of dust by filtration through cotton, and dried by chloride of potassium or other dessicatives. The substance which seems to produce the least wear on alloys of platinum and iridium is ivory, which has the further advantage of resisting moisture and other atmospheric influences, as is shown by cave fossils. The standard weights should, therefore, be kept in glass cylinders, with ivory caps at top and bottom.—*Comptes Rendus.* C.

Electrical Phenomenon at Potenza.—Cappanera finds that natural electric currents often traverse the telegraphic wires, which are strongest in the neighborhood of the volcanic terrace of Vultures. They are most noticeable in October, November, December, March and April, especially during falls of snow.—*Bull. del Vulc. Ital.* C.

Biermann's Wolfram-bronzes.—Biermann, in Hannover, furnishes a Wolfram-bronze which contains, according to Strohmeyer, 95·39 per cent. of copper, 3·04 per cent. of tin, 1·57 per cent. of wolfram. It is very tough, malleable, ductile, and of great absolute strength. An addition of from 1·5 to 2 per cent. of wolfram increases the hardness four or five-fold, without diminishing the toughness. The bronze requires, for working, a temperature 100° higher (180°F.) than ordinary brass, and can only be cast in very dry sand or in iron moulds.—*Berg- u. Hütten-Ztg.* C.

On Uralium, a New Metal of the Platinum Group. A. Guyard.—As far back as 1869 the author discovered this metal in commercial platinum obtained from Russian ores. Next to silver it is the whitest metal known; its malleability is as great as that of the purest platinum, but its ductility is much greater, and it is almost as soft as lead. Its melting point lies near to that of platinum, and it is not volatile. Its specific gravity is 20·25, and its molecular volume, like those of osmium, platinum and palladium, is 6·25. Its atomic weight has been found to be 187·25. In its chemical properties it is difficult to distinguish from platinum.—*Chem. News.*

New Element.—Tellef Dahll has found a new element, which he calls *norwegium* (Ng.), in a compound of arseniuret of nickel and nickel glance. It is white, somewhat malleable, of copper-like hardness, melting at a red heat, density 9·44. It dissolves with difficulty in hydrochloric acid or sulphuric acid, easily in nitric acid. The solution is blue, becoming green if diluted with water. Two specimens gave an atomic weight of 145·95. It is precipitated by caustic potash, ammonia and carbonate of soda; the green precipitate is soluble in all these reagents and giver blue solutions. Sulphuretted hydrogen gives, even in very acid solutions, a brown precipitate insoluble in sulphuret of ammonia. Borax, in the oxidizing flame, gives a yellowish green gloss, becoming blue in cooling. The blue color is shown in the reducing flame. It is easily reducible with carbonate of soda, or upon carbon.—*Comptes Rendus.* C.

Gum Arabic Solution.—The adhesiveness and durability of a solution of 100 parts gum arabic in 250 parts water may be increased by adding 2 parts of sulphate of alumina.—*Polytech. Notizbl.* C.

Artificial Quartz Crystals.—MM. Friedel and Sarrazim have obtained quartz crystals by the action of hydrochloric acid upon gelatinous silica in closed vessels, at a temperature of 350° (662°F.).—*Soc. Chim. de Paris.* C.

Defoy's Electric Bit.—The reins enclose a small conducting wire, extending from the bit to a small electro-magnet. By turning the crank of the electro-magnet, a slight current is sent to the horse's mouth, causing such surprise that he stands immovable, and is easily tamed by caresses. The current is not strong enough to give a shock or to stupefy the animal.—*Les Mondes.* C.

Heat of the Electric Arc.—Prof. Rosetti, of the University of Padua, has measured the temperatures of the electric arc and of the carbon points. With 80 Bunsen elements he found for the negative 2400° (4352°F.), for the positive pole 2870° (5198°F.), and for the arc 359° (6332°F.). These temperatures decrease with an increase in the number of elements employed.—*Soc. Franc. de. Phys.* C.

Electric Light in Persia.—Fabius Boital recently exhibited the Jablochkoff light before the Shah of Persia. When the machine was started, the Shah turned on the light by a gentle pressure, and all the bystanders gave a shout of admiration, which was repeated when they found that the street lights were kindled at the same instant. M. Boital has been engaged to introduce a large supply of electrical apparatus, to build extensive gas-works, to erect a series of dwellings of a plan and architecture hitherto unknown in Teheran, and to construct an Industrial Palace.—*Les Mondes.* C.

Paper Window-shutters.—William Hipkins, of Belair, Ohio, has taken out a patent for window-shutters in which pasteboard is substituted for wood. The slats and panels can be covered with colored or stamped paper, so as to imitate any desired kind or pattern of wood. The inventor claims as advantages for such shutters that they are lighter and cheaper than wood, that they do not warp or split, that they can be easily fitted to new positions, that they are susceptible of a great variety of patterns, and that they will contribute to an improvement in the appearance of cheap dwellings.—*Fortsch. der Zeit.* C.

Speaking Dictionary.—M. Lambrigot has invented a modification of Edison's phonographic matrices, by substituting stearine for the tin foil, and electrotyping the impressed surface. It has been suggested that these electrotypes, which can be made very cheaply, may render great service in the study of foreign languages, for they preserve indefinitely and repeat as often as may be desired words that are the most difficult to pronounce correctly. A true speaking dictionary might thus be made, an undertaking which the wildest fancy would not have dreamed of a few years ago.—*Le Nature.* C.

Electrolysis in Soda Manufacture.—M. Merle, the manufacturer of the chemical works of Merle & Co., has erected electrical machines, which are employed to eliminate, by means of electrolysis, the whole of the iron and other metals, such as lead and arsenic. The separation of these metals is effected very rapidly, in large quantities, at a comparatively small cost. The soda crystals which are obtained from the concentration of the leys are very white, and well adapted to the bleaching of fabrics previous to drying. The manufacture of soda crystals and caustic soda, in the south of France, is very difficult, on account of the high temperature, which makes the mother liquors too rich in carbonate of soda. C.

Distribution of Power by Electricity.—Numerous experiments have lately been made in Paris on the transmission of power by means of two Gramme machines, one producing an electric current by mechanical action, the other operating inversely, and reconstituting a portion of the labor which was originally expended. In order to make careful measurements, M. Tresca estimated some of the experiments with a Gramme machine making 1200 revolutions per minute. The current was transmitted, by copper wires, to carts at different distances, two Gramme machines being placed on the carts and acting on a windlass, which pushed a double Brabant plough so as to make a furrow 220 metres (240·6 yds.) long. The velocity of the plough, when the circuit of the current was 800 metres (874·91 yds.), was 88 centimetres (34·65 in.) per second, the shaft making 1123 turns per minute; when the circuit was increased to 1300 metres (1421·72 yds.), the velocity was increased to 70 centimetres (27·56 in.) and the revolutions of the shaft to 890. The effective work was estimated at three horse-power.—*Comptes Rendus.* C.

Book Notices.

FRICTION AND LUBRICATION. Prof. R. H. Thurston. 1 vol., 8vo, 212 pages. The Railroad Gazette, New York, 1879.

It will be hard to over-estimate the value of the experimental results given in this little work to the mechanical engineer.

Heretofore the results given in published works have in many points been incomplete, if not grossly erroneous.

While Prof. Thurston's results will not carry with them to the minds of others such positive convictions as seem to have arisen in his own, nor will his deductions always be applicable to the ordinary cases occurring in mechanism without the introduction of a large factor of safety, still, thanks to his labors, the practitioners of engineering are now in possession of a mass of data such as will serve as a guide in a field hitherto almost unknown.

A careful study of the tables shows the overpowering influence which the temperature of the journal has upon the coefficient of friction, and the necessity which exists of keeping journals at some fixed temperature which has been found most economical for the lubricant used, or which does not affect injuriously the working of the machine under consideration.

This constant temperature is an unavoidable necessity in actual practice, and must be attained; and on this point, upon which Prof. Thurston does not seem to have laid sufficient stress, we have most valuable information in the experiments of Mr. A. H. Van Cleve, given on page 155.

This table clearly shows that where the lubricant is supplied at a uniform rate and an approximately constant temperature of journal is held, that the work or heating which a journal will withstand at varying speeds and pressure closely approximates to a uniform quantity, and therefore that in practice the length of the journal is the only factor to be considered in order to prevent heating, the diameter of the journal being afterward so established as to prevent undue pressure or abrasion.

On page 56 Prof. Thurston gives, without stating any reason when he states the fact, the following formula for the length of journal bearing

$$l = \frac{P\ V}{60000d}$$

in which $l =$ the length of the journal in inches, $P =$ the load in lbs., $V =$ the velocity in feet per minute, and $d =$ the diameter of the journal in inches.

It is difficult to make use of this formula, because it is necessary to assume a value for d.

It is comparatively easy to simplify this formula so as to avoid the necessity of assuming a value for d. Taking for example the first experiment of Van Cleve, on page 155, we find the pressure per square inch to be 167 lbs., and the velocity of the rubbing surfaces to be 196·35 feet per minute. From the table, page 185, we find, with sufficient approximation *for the most favorable conditions possible*, that the coefficient of friction is one-half of one per cent., and therefore that the work per square inch of area is

$$\frac{167 \times 196{\cdot}35}{200} \text{ ft. lbs.} = 163{\cdot}62 \text{ ft. lbs.} = 1963{\cdot} \text{ inch lbs.}$$

Now, letting $N =$ the number of revolutions per minute, and $f =$ the coefficient of friction, we have for the work of friction per square inch of area,

$$f \frac{P}{l\,d} \times \pi\, d\, N = \pi f \frac{P'\,N}{l}$$

If we equate this with the work just derived from experiment, we have

$$l = \frac{\pi f}{1963} P'\,N$$

P' and N are always known, and f may be determined from inspection of the tables of experiments and a sufficient increase be made to cover contingencies.

Many times when lines of shafting are taken down the journals will be found to have worn smooth in only a small part of their length, and in the case of crank pins and journal bearings, their heating, where there is the least lack of rigidity or the engine is out of line, defies all precautions.

The wear and tear of mechanism will not permit the use of the coefficients given in the tables, in ordinary practice, without large increase.

Conclusion 11, page 211. "The only method of learning the true value of a lubricant is to place it under test," is in brief the result of the many and varied experiments set forth.

The elaborate descriptions of testing machines and methods of testing oils are of great interest to all engineers and intelligent mechanics.

The work is well worth the careful reading of every one interested in the mechanic arts. It is much to be regretted that the faith of the reader in the accuracy of the tables is shaken by the slovenly proof-reading, discovered where errors are easily detected. M.

COMPUTATION OF TIME AND CHANGES OF STYLE IN THE CALENDAR. Addressed to Students of History and Genealogy. By Spencer Bonsall. Reprinted from the "Pennsylvania Magazine of History and Biography," Vols. II, III.

In this pamphlet the author has collected a mass of valuable information respecting the Julian and Gregorian Calendars, the Calendar of the Society of Friends, the Ecclesiastical and Historical Years, the Calendar of the French Republic from 1792 to 1806, and the dates at which the new style was adopted in the principal countries of Europe. The mistakes which are frequently made, even by literary men, when writing of past events; the fickle action of Roman pontiffs, who changed the year capriciously, so as to lengthen or shorten the period during which a magistrate remained in office; the details of the reformation introduced by Pope Gregory XIII; the rules for determining the day of the week for past or future events; the action of the Nicene Council in fixing the days on which Easter and other movable feasts should be celebrated; the frequent adherence to the old style in England, by making rents payable on the old quarter days, and many other items of interest have been collected with an industry and fidelity which deserve great commendation.

In preparing the work, the statements of the best authorities were collated, and information which was found scattered in various volumes was brought together in a condensed form. Many useful suggestions are given to students, and a brief appendix is added of notes on sundry calendars, by Alexander Wilcocks. The whole may be read with pleasure by all who are merely in search of general information, and special students of history or genealogy will probably find in its pages every important fact in relation to the subject which is accessible anywhere. C.

SANITARY ENGINEERING; a Guide to the Construction of Works of Sewerage and House Drainage. With Tables for Facilitating the Calculations of the Engineer. By Baldwin Latham, C. E. New York: G. H. Frost, 1877. 4to, pp. 72.

The importance of good sewerage is being more and more recognized, and it is therefore gratifying that the above work, which is the only complete and systematic treatise on the subject, has been republished and is sold at a price which makes it accessible to all who are interested in the matter. Although specially adapted to English practice, it contains the guiding principles which can readily be adapted to local conditions and peculiarities.

Beginning with a general inquiry into the character of the district to be sewered, viz., the geological, physical and topographical features, the rainfall, water supply and population, the author shows their respective bearings on the proper design of the works. He then enters into the discussion of the course, size and grade of sewers necessary to make them self-cleaning and otherwise efficient. The merits of the various sectional forms are carefully considered, together with the relative advantages of the materials used in building them. We are then informed of the importance of a proper mode of making the junctions with sewers, of providing flushing arrangements, and due space is given to the subjects of ventilation and trapping. The closing chapters are on house drainage.

The American publisher has appended a very full set of specifications for the construction of a large sewer in New York city, and a translation of the very valuable pamphlet, "The Planning and Building of Sewers," by J. Chailly, both of which greatly add in worth to the above work. The text is fully illustrated with 19 large quarto plates. H.

Franklin Institute.

HALL OF THE INSTITUTE, Dec. 17th, 1879.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 174 members and 66 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that 17 persons were elected members of the Institute at their last meeting.

The Secretary reported the following donations to the Library:

Reports and Awards. Internat'l Exhibition, 1876. Philadelphia. J. B. Lippincott & Co. 1878.

Report of the Director General. Intern. Exhibition, 1876. Philadelphia. J. B. Lippincott & Co. 1879.

Grounds and Buildings of Centennial Exhibition. Philada., 1876.

Reports of the President, Secretary and Executive Committee Centennial Exhibition. Philada. J. B. Lippincott & Co. 1879.

Appendix to the Reports of the United States Centennial Commission and Board of Finance. Philada. J. B. Lippincott & Co. 1879.
From the United States Centennial Commission.

American Engineering. Illustrated. By G. Weissenborn, N. Y. 2 vols. From Fred'k Graff.

Report of Twelfth Annual Convention of the American Railway Master Mechanics' Association. 1879. From the Association.

American Engineering, as illustrated by the Amer. Society of Civil Engineers at the Paris Exposition of 1878.
From John Bogart, New York.

Report of Prof. S. F. Baird, Secretary of the Smithsonian Institution, for 1878. From the Institution.

Bulletin of the U. S. Geol. and Geog. Survey of the Territories. Vol. V, No. 2. Washington. 1879.
From the Dept. of the Interior.

Annales de Chimie et de Physique, par MM. Chevreul, Dumas, etc. 3d Ser. Vols. 49—51 in one vol.
From Mr. Henry Pemberton, Philadelphia.

Second Geological Survey of Pennsylvania. Reports M2, P and V.
From the Board of Commissioners of the Survey, Harrisburg.

Annual Report of the Council of the City of Manchester on the Working of the Public Free Libraries. 1878–'79.
From the Council.

U. S. Geol. and Geog. Survey of Colorado and adjacent Territory. 1876. Tenth Report. by F. V. Hayden.
Report on the Geology of the Henry Mountains. By G. R. Gilbert. Washington. 1877.
Report on the Lands of the Arid Region of the United States. With Maps. By J. W. Powell.
From the Interior Department, Washington.

Geological Survey of Canada. Report of Progress from its Commencement to 1863. Atlas of Maps and Sections. Montreal. 1865.
Report of Progress for 1877–78. With Maps. Montreal, 1879.
Notes on the Gold of Eastern Canada. Montreal. 1864.
Remarks on the Mining Region of Lake Superior. By W. E. Logan. Montreal. 1847.
Petroleum. Its Geological Relations in Gaspé. Quebec. 1865.
Canada. A Geographical, Agricultural and Mineralogical Sketch. Quebec. 1865.
Report on Fossil Plants. By J. W. Dawson. Montreal. 1871 and 1873.

New Species of Lower Silurian Fossils. By E. Billings. Montreal. 1861.

Lawrenthian Limestones of North America. By T. S. Hunt.

Esquisse Geologique du Canada. Paris. 1867.

Descriptive Catalogue of a Collection of the Economic Minerals of Canada. 1862.

Report of Dr. T. S. Hunt on the Gold Region of Nova Scotia. Ottawa. 1868.

Reports of Mr. A. Michel and Dr. T. S. Hunt on the Gold Region of Canada. 1866.

Catalogue des Mineraux, Roches, etc., du Canada. Par B. J. Harrington and A. C. Sellwyn. London. 1878.

Catalogue of Silurian Fossils. By E. Billings. Montreal.

Descriptive Catalogue of a Collection of the Economic Minerals of Canada; and Notes. Montreal.

Palæozoic Fossils. Vol. 1, 1861–'65. Vol. 2, Pt. 1, 1874. Montreal.

Figures and Descriptions of Canadian Organic Remains. Decades 1—4. Montreal. From the Geological Survey of Ganada.

Specifications and Drawings of Patents. July, 1879.
From U. S. Patent Office.

Fifty-Ninth Annual Report of the Managers of the Apprentices' Library Co. Philadelphia. From the Company.

J. Snowden Bell, Esq., read a paper on "Locomotive Spark Arresters," and some remarks were made on the subject by Mr. John W. Nystrom.

Mr. George Richards read a paper on "Standard Sizes in Cylindrical Fitting," which was discussed by Mr. William Sellers and other members.

Mr. Richard S. Rhodes gave some account of his "Audiphone," and several forms of the instrument were exhibited.

Dr. J. Cheston Morris read a short paper on "Improved Methods of Milk Shipment."

The Secretary's Report inclosed an account of the "Victor Automatic Fire Extinguisher," invented by Mr. E. Leonard; Janesville Safety Lamps; Hydro-Carbon Heating Apparatus; Edison's New Phonograph; Wilson's Touroscope; Cabinet Orguinette of Mr. Wm. Blasius; Tyson's Improved Motor for Sewing Machines, etc.; Lester's Milk Cans; Warren Milk Bottles; Robertson's Horse Shoe; Kuhnle's Patent Stair-rod Holder; and Gelatine Duplicating Sheets.

The President announced that, in accordance with Article XIV, Section 7, of By-Laws, nominations should be made at this meeting for a President, two Vice-Presidents, Secretary, Treasurer, eight Managers, to serve for three years, and two Auditors, one for two years and one for three years.

Mr. Jones nominated the retiring members of the Board.

The following members were placed in nomination:

For President, William P. Tatham.

For Vice-Presidents, Henry Cartwright, Charles Bullock, T. Morris Perot and Henry G. Morris.

For Secretary, Dr. Isaac Norris and Hector Orr.

For Treasurer, Frederick Fraley.

For Managers, A. B. Burk, J. Smethurst, Fred. Graff, J. Eccles, S. Sartain, C. Bullock, E. Lewis, W. Helme, C. H. Banes, C. Chabot, Prof. E. J. Houston, Prof. Persifor Frazer, Jr., J. G. Baker, A. H. Disston, R. McCambridge, J. J. Weaver and Dr. C. M. Cresson.

For Auditors, W. A. Cheney and W. Biddle.

For Representative in Pennsylvania Museum and School of Industrial Art, Dr. Isaac Norris.

The President appointed the following members to act as tellers at the annual election to be held Jan. 21st, 1880: W. L. Dubois, John Canby, Samuel Sartain, G. M. Sandgran, J. W. Nystrom, J. J. Weaver, and W. B. Cooper.

On motion of Mr. Heyl, it was

Resolved, That the Secretary be directed to have printed a sufficient number of lists of nominations to serve as ballots at the annual election, and also to send one to each member with the notice of next stated meeting.

On motion of Mr. Nystrom, it was

Resolved, That the Secretary is hereby authorized to ask permission of the Hartford Boiler Insurance Company to procure for the Institute from Messrs. Newall & Sons photographic lantern slides of the Wilt & Sons boiler, for the purpose of exhibiting the same at the next meeting of the Institute.

On motion the meeting adjourned.

ISAAC NORRIS, M. D., *Secretary pro tem.*

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ON THE ANGULAR PITCH OF SQUARE-THREADED SCREWS.

By WILFRED LEWIS.

The efficiency of any mechanism is measured by the ratio of its useful work to the work consumed. This is always an important factor in determining the excellence of machinery, and it deserves special consideration in the case of feed and lifting screws, which often form essential elements of a design.

The screw may be used, in practice, either as a means of performing work, or for the purpose of binding and holding together various parts of machines or structures. In the latter case the thread is generally V-shaped, and its pitch and depth are determined by a recognized standard. Here the stability of constructions demands a small angular pitch, to prevent the possibility of jarring loose.

In the former case the square thread is the common and approved form, but no special standard of pitch is strictly adhered to, and inclinations ranging from 5° to 30° are often used.

The efficiency of a screw is increased by the reduction of its frictional work, which will be found to depend upon the coefficient of friction, the angular pitch of the thread, the shape of the thread, and the diameter of the supporting step or collar. It is, therefore, desirable in cases where the screw is used to perform work, that its frictional resistance should be reduced to a minimum, and it is the object of this paper to investigate the relation between angular pitch and frictional work, and to derive a general formula by which the angle corresponding to the least amount of frictional work can be determined.

The first step necessary toward the reduction of friction is that the thread shall be square. This seems to be well understood, and calls for no special demonstration. It will suffice to say that the friction is proportional to the cosec. of the angle which the generating line of the thread makes with the axis of the screw.

The most common pitch for square threads is double that of V threads for the same diameter, but in the case of feed and lifting screws this is sometimes doubled, or even trebled, and it is found to be true that the work done in overcoming a given resistance or in lifting a given weight is thereby lessened.

The reason of this is apparent, for in screws of very fine pitch it will be seen that an undue amount of work is performed by the excessive sliding. On the other hand, it is also evident that if too coarse a pitch be used the power of the screw will be again lost in friction.

It therefore becomes necessary to determine that point at which the least amount of work will be absorbed by friction.

The angle at which this takes place must be a function of the frictional resistances, for were friction left out of consideration the work done in raising a given weight a given distance would be constant and independent of the pitch used.

The force necessary to slide a weight up or down an inclined plane is clearly demonstrated in Weisbach's Mechanics, and a similar construction will serve to determine the force required to overcome the resistance of a screw.

Let the right angled triangle ABC be the development of a spiral, the angle α being equal to the angular pitch, which is the angle of the spiral to a plane normal to the axis of the screw. Given the weight of the block O, represented by OW, to find the magnitude of the force parallel to AC, which will cause the block to slide up the incline AB. S_0 is the component of W along AB, and N_0 the normal component.

S_1 is the component of P along AB, and N_1 the normal.

$N_0 + N_1 = W \cos. a + P \sin. a$, $S_1 - S_0 = P \cos. a - W \sin. a$

Let φ = coefficient of friction, then

$$P \cos. a - W \sin. a = \varphi\ W \cos. a + \varphi\ P \sin. a$$

or $$P \cos. a = W \sin. a + \varphi\ (W \cos. a + P \sin. a)$$

multiplying by cosec. a

$$P \cot. a = W + \varphi\ W \cot. a + \varphi\ P$$

whence $$P (\cot. a - \varphi) = W + \varphi\ W \cot. a \text{ and}$$

$$P = \frac{W + \varphi\ W \cot. a}{\cot. a - \varphi} \tag{1}$$

This force P multiplied by the mean radius of the screw will give the twisting moment required to raise a given weight without step or collar.

Similarly it may be shown that the force required to lower a given weight may be expressed by the equation

$$P_1 = \frac{\varphi\ W \cot. a - W}{\cot. a + \varphi} \tag{2}$$

The moment required to overcome the resistance of a step or collar is equal to $\varphi\ W$ into the mean distance of the rubbing surface from the centre of the screw.

Let R = outside radius of collar.

Let r = inside " "

Then it can readily be shown that the mean radius

$$r_0 = \tfrac{2}{3}\ \frac{R^3 - r^3}{R^2 - r^2} \tag{3}$$

The same formula may be used to determine the mean radius of the screw, but, inasmuch as r is seldom less than $\cdot 8\ R$, it will in most cases be sufficiently accurate to assume for the pitch diameter of the screw the diameter at the middle of the thread.

If d = pitch diameter of screw, and

D = " " " step or collar,

then $\frac{D}{d} = n$ will express the ratio of the effective lever arms of collar and thread.

The total force acting at the pitch line of the screw required to overcome all resistances will then be expressed by

$$P = \frac{W + \varphi\ W \cot. a}{\cot. a - \varphi} + n\,\varphi\ W. \tag{4}$$

The work done in raising a weight through the distance BC, considered as unity, will be expressed by the equation, P cot. $\alpha =$ work done $=$

$$W \cdot \frac{\cot.\ \alpha + \varphi \cot.^2 \alpha}{\cot.\ \alpha - \varphi} + n\,\varphi\,W \cot.\ \alpha. \qquad (5)$$

By differentiating and equating to zero, the following expression is obtained for the angle corresponding to the least amount of frictional work,

$$\cot.\ \alpha = \varphi + \sqrt{\frac{1+\varphi^2}{1+n}}. \qquad (6)$$

Thus when the coefficient of friction and the value of n are known, the angular pitch corresponding to the greatest efficiency is readily obtained.

For example, let the coefficient of friction be ·15, and let the screw be supported upon a step equal in diameter to the root of the thread, in which case n will equal about ·5.

Then, applying the formula

$$\cot.\ \alpha = \cdot 15 + \sqrt{\frac{1+\cdot 0225}{1+\cdot 5}} = \cdot 9525$$

$$\alpha = 46^\circ\ 23'$$

The most efficient pitch will in general be steeper than can be conveniently made in practice, and it is besides open to the objections of necessitating a large increase in diameter, and of diminishing the power.

In order to choose an advantageous pitch, with least sacrifice of power or material, plates 1 and 2 have been constructed.

In plate 1 abscissæ denote the angular pitch of the thread, and in plate 2 they denote the long or axial pitch in terms of the pitch diameter of the screw.

Plate 2 has been constructed by substituting the corresponding ordinates in plate 1, and is given as a form more convenient for practical use.

In these plates the coefficient of friction has been assumed at ·15, as determined from experiments to be described.

Ordinates from the horizontal line aa, measured to the curves de and df, are proportional to the force required at pitch of screw to raise or lower a given weight when $n = 0$.

Ordinates are to be measured from n, n', n'', when $n = \cdot 5$, $1 \cdot 5$ and

3, respectively. From which it follows that the points of intersection of df with a, n, n' and n'' give the greatest angle at which the screw will stand without running down in those particular cases.

Ordinates measured from aa to gh and gk represent, respectively, the diameters of screws for equal torsional strength and for equal angular deflection.

Ordinates from BB to the curves A, N, N' and N'' represent the total work done when $n = 0, \cdot 5, 1\cdot 5$ and 3.

$BC =$ useful work done, and ordinates above $CC =$ frictional work.

From plate 1 it becomes evident that by the reduction of n' to n, or a change from an ordinary collar to step bearing, that a screw whose pitch was 5° might be increased to 13° without sacrifice of power, and with a saving of ·6 of the work consumed by friction.

To find the force required to turn a V-threaded screw, let $\beta =$ angle which generating line of thread makes with the axis, then from equation (4)

$$P = \text{cosec.}\, \beta \, \frac{W - \varphi\, W \cot.\, \alpha}{\cot.\, \alpha - \varphi} + n \varphi\, W. \tag{7}$$

In the U. S. standard V thread, $\beta = 60°$ and $\alpha = 2\frac{1}{2}°$ about, and the value of n for a nut or bolt head $= 1\cdot 5$ nearly.

Then, by substitution in the above formula,

$$P = \left(1\cdot 15 \, \frac{1 + \cdot 15 \times 22\cdot 9}{22\cdot 9 - \cdot 15} + 1\cdot 5 \times \cdot 15\right) W = \cdot 45 \; W$$

When friction is disregarded P should equal tan. $\alpha\, W = \cdot 0437\; W$. Hence it is evident that the stress upon a standard V threaded bolt will be only $\frac{\cdot 0437}{\cdot 45}$, or ·1 of the stress calculated in disregard of friction, and this has been actually confirmed by experiment.

Similarly it may be shown that the stress upon a common square threaded bolt whose angular pitch = 5° is ·19 of that calculated in disregard of friction.

The stress exerted by a given force P will be practically the same in either case, although the square thread is double the pitch of the V, and this is a striking proof of the disadvantage of using very fine pitches.

The coefficient of friction ·15 was determined by experiments upon the feed screw of a 36-inch vertical drill at the machine works of Wm. Sellers & Co. The essential features of the apparatus are shown in Fig. 2.

The feed screw to which the spindle is attached is suspended in a cast iron nut, and is prevented from revolving with the nut by links at A.

A cord was wound around the circumference of this nut, to which, after passing over a pulley, weights were suspended at F. Weights ranging from 50 to 2000 lbs. were suspended at W, and the force at F necessary to start the nut as well as to keep it in motion was carefully determined in each case.

It was in general found that the force required to start the nut was about 1·3 times that required to keep it in motion, and that the force required to keep it in motion varied slightly with the speed, growing less as the speed increased.

But inasmuch as there was no available means of determining the rate of motion, the speed was kept as slow as possible. Due allowance was made for the friction of the pulley and the coefficient φ calculated by substitution in equation (4).

It is sometimes necessary, apart from the questions of torsional strength and angular deflection, to know the combined effects of torsion and tension upon a movable nut worked by the screw, in order to insure steadiness of motion. In other words, to find the ratio of the diameters of screws of various pitches in which the total resilience shall be constant.

Thus, let it be required to find the diameter of any screw whose total resilience shall be equal to that of a screw whose diameter is unity and angular pitch indefinitely small.

The elastic extension of wrought iron under a proof load of 30,000 pounds, is, according to D. K. Clark, about ·0011 times its length, and it can be deduced, from the formulæ for deflection given by the same author, that a load of 30,000 pounds applied at the circumference of a shaft of 1 inch section will produce a circular deflection of ·0154 times the length of the shaft. It therefore follows that when $P = W$ the ratio of circular deflection to linear extension will be $\frac{\cdot 0154}{\cdot 0011} = 14$, and if the linear extension be assumed at unity the circular deflection will be 14 times $\frac{P}{W}$, as calculated by equation (1), or by 14 P when W is assumed at unity, and for the sake of simplicity this assumption will be made in all subsequent formulæ.

The resilience of extension is felt directly by the movable nut, but that of circular deflection must be multiplied by the tangent of the angular pitch, to determine its effect upon the steadiness of motion. Both vary inversely as the square of the diameter of the screw when the resistance is constant, and hence the conditions necessary to insure equal steadiness of motion in screws of various pitches, having the same resistance to overcome, are expressed by the equation

$$\frac{1 + 14\ P \tan.\ \alpha}{d^2} = \text{a constant.}$$

The ratio of the diameters can, therefore, be determined by the equation

$$d = \sqrt{1 + 14\ P \tan.\ \alpha} \qquad (8)$$

By substituting the values of tan. α the following values of d are obtained :

When $\alpha = 0°$ $d = 1$ When $\alpha = 5°$ $d = 1{\cdot}13$
" $\alpha = 10°$ $d = 1{\cdot}35$ " $\alpha = 20°$ $d = 1{\cdot}94$
" $\alpha = 30°$ $d = 2{\cdot}74$ " $\alpha = 40°$ $d = 3{\cdot}64$
" $\alpha = 50°$ $d = 5{\cdot}14$ " $\alpha = 60°$ $d = 7{\cdot}75$

For steel the ratio of circular deflection to linear extension may be taken at 7, and a curve similar to that for wrought iron calculated by the formula

$$d = \sqrt{1 + 7\ P \tan.\ \alpha} \qquad (9)$$

The curve of diameters for uniform total resilience in wrought iron is represented by dl, and thus the power, strength, stiffness, resilience and frictional work for any pitch can at once be seen.

Another curve, showing the comparative steadiness of motion in screws of the same diameter but of different pitches, might be computed by the formula $1 + 14\ P \tan.\ \alpha =$ comparative resilience of screws of constant diameter.

The application of the preceding principles to differential screws shows an enormous loss in frictional work without the commonly supposed gain in power.* If, in Fig. 2, the cast iron nut which revolves upon its bearing should be made to move longitudinally, by having a thread, whose pitch should be in the same direction as the internal thread, cut upon its outer surface, then the advance of the spindle would be measured by the difference in axial pitch of the two screws.

---

* The word power is used advisedly in the sense of force, and nothing more than the relation $\frac{W}{P}$ should be understood by it.

The throw of the spindle, however, would be necessarily much restricted by such an arrangement, and the substitute is sometimes resorted to, of making the screw and nut both revolve in the same direction by suitable gearing.

In either case the object of the device is to multiply the power without reducing the size of the thread to that of a corresponding simple screw and nut.

How much the power may be multiplied can be determined from a general solution for each case.

In the first case, let

$a =$ diam. of external screw; $e =$ axial pitch of external screw;
$b =$ “ internal “ $f =$ “ “ internal “
$\frac{b}{a} = d =$ ratio of diameters; $\frac{f}{e} = p =$ ratio of pitches;
$\alpha =$ angular pitch of external screw;
$\beta =$ “ “ internal “

Then $\cot. \alpha = \frac{\pi a}{e}$, and $\cot. \beta = \frac{\pi b}{f} = \cot. \alpha \frac{e b}{a f} = \frac{\pi d a}{p e}$

The force required at pitch line of external screw to move it against a resisting weight can be determined from equations (1) and (2), and may be expressed by

$$F = P + P^1 = \frac{1 + \frac{\varphi \pi a}{e}}{\frac{\pi a}{e} - \varphi} + d \frac{\frac{\varphi \pi d a}{p e} - 1}{\frac{\pi d a}{p e} + \varphi} \qquad (10)$$

and the force required to turn it in the opposite direction will be given by the equation

$$F_1 = P_1 + P = \frac{\frac{\varphi \pi a}{e} - 1}{\frac{\pi a}{e} + \varphi} + d \frac{\frac{\varphi \pi d a}{p e} + 1}{\frac{\pi d a}{p e} - \varphi} \cdot \qquad (11)$$

The direction in which the external screw should be turned in order to perform work against resistance, depends upon the relative magnitudes of e and f.

When $e > f$, equation (10) expresses the force required to raise a weight, and equation (11) the force required to lower it, and *vice versa.*

For example, let $a = 2 \cdot b = 1 \cdot e = \cdot 5$, and $f = \cdot 4$, then $d = \cdot 5$ and $p = \cdot 8$, and applying formula (10):

$P = \cdot 2325$, $P_1 = \cdot 0111$, and consequently $F = \cdot 2436$

Also from formula (11):

$P_1 = \cdot 07$, $P = \cdot 1115$, and $F_1 = \cdot 1815$

Here there is actually less power gained than could have been derived from the outside screw alone when used without step or collar.

The total work done is given by the formula

$$U = \frac{F \pi a}{e - f} = \frac{\cdot 24 \times 3\cdot 14 \times 2}{\cdot 1} = 15\cdot 7$$

times the useful work.

When the screw and nut both revolve with different angular velocities there are three pairs of rubbing surfaces, the step upon the screw, the collar upon the nut, and the screw threads themselves.

Let n = ratio of effective diameters of step and screw;
" $n^1 =$ " " " nut "
" a = angular pitch of screw;
" $v =$ " vel. "
" $v^1 =$ " " nut.

Then, when $v > v^1$ the force required to turn the screw at its pitch line against a resistance can be expressed by the equation

$$F = \frac{1 + \varphi \text{ cot. } a}{\text{cot. } a - \varphi} + n\,\varphi + \frac{v^1}{v}\left(n^1\,\varphi - \frac{1 + \varphi \text{ cot. } a}{\text{cot. } a - \varphi}\right) \qquad (12)$$

and when $v^1 > v$, the equation becomes

$$F = \frac{1 + \varphi \text{ cot. } a}{\text{cot. } a - \varphi} + n^1\,\varphi + \frac{v}{v^1}\left(n\,\varphi - \frac{1 + \varphi \text{ cot. } a}{\text{cot. } a - \varphi}\right) \qquad (13)$$

The force required to lower a weight when $v > v^1$ is

$$F_1 = \frac{\varphi \text{ cot. } a - 1}{\text{cot. } a + \varphi} + n\,\varphi + \frac{v^1}{v}\left(n^1\,\varphi - \frac{\varphi \text{ cot. } a - 1}{\text{cot. } a + \varphi}\right) \qquad (14)$$

and when $v^1 > v$ the equation becomes

$$F_1 = \frac{\varphi \text{ cot. } a - 1}{\text{cot. } a + \varphi} + n^1\,\varphi + \frac{v}{v^1}\left(n\,\varphi - \frac{\varphi \text{ cot. } a - 1}{\text{cot. } a + \varphi}\right) \qquad (15)$$

To take an example, let $n = \cdot 5$, $n_1 = 1\cdot 5$, $a = 5°$, $v = 3$, and

$v^1 = 2$, then from equation (12) $F = \cdot 305$ The ratio of the total work consumed to the useful work done can be obtained from this by the formula

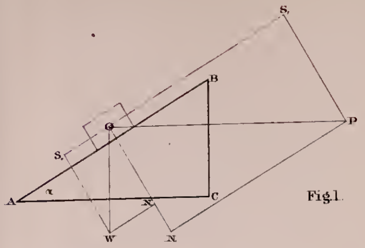
$$U = F \cot. \alpha \frac{v}{v - v^1} \qquad (16)$$

when $v > v^1$, or by

$$U = F \cot. \alpha \frac{v}{v^1 - v} \qquad (17)$$

when $v^1 > v$, and for the present case $U = 10{\cdot}46$. The same screw working in a fixed nut would give $P = \cdot 315$ and $U = 3{\cdot}6$, and thus from the above formula the power and efficiency for either form of differential screw can be determined, and the inefficiency and absurdity of any particular case thereby demonstrated.

Explosion of Carbonic Acid in a Coal Mine.—Delesse gives an interesting account of a remarkable explosion in the coal mine of Rochebelle. Two miners who were at work in a shaft, at a depth of 345 metres (377·3 yards), heard a noise like a blast, but shorter; less than a minute afterwards they heard a second report, louder than the first, but which was not heard by the attendant at the opening of the shaft. Their lamps were extinguished and they felt great oppression, but were able to give the signal so as to be drawn to the surface, and thus escape death. Three miners were suffocated in the galleries leading from the shaft. The explosions were at first attributed to fire-damp, but the bodies and clothing of the victims showed no trace of fire; none of the loose gunpowder or cartridges took fire. No fire-damp has ever been observed in the mine, but occasional outbursts of carbonic acid have been noticed and guarded against by special ventilation. On examining the locality of the explosion a hole was found not less than 6 metres deep (6·562 yards), and of capacity sufficient to have contained about 76 tons of coal. Delesse attributes the explosion to the action of sulphuric acid, generated by iron pyrites, gradually dissolving in the subterranean waters and penetrating to underlying beds of limestone. The gas penetrating the crevices of the coal would accumulate, producing a constantly increasing pressure until it acquired force enough to make the explosions.—*Comptes Rendus.* C.


S,
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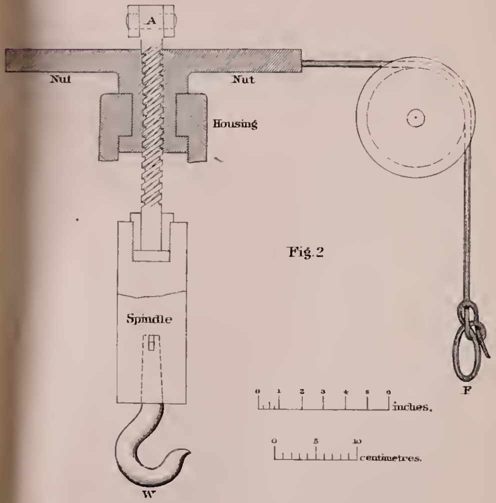
W
N

Fig.1.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Nut
Nut
Housing
Spindle
W
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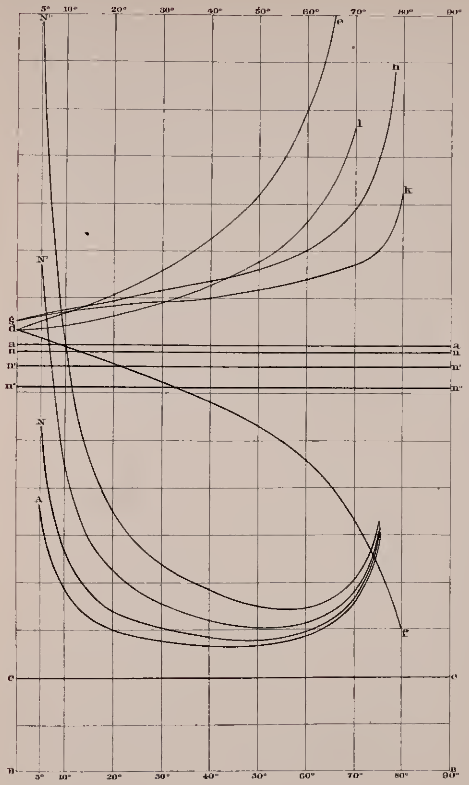
0 1 2 3 4 5 6 inches.
0 5 10 centimetres.

Fig.2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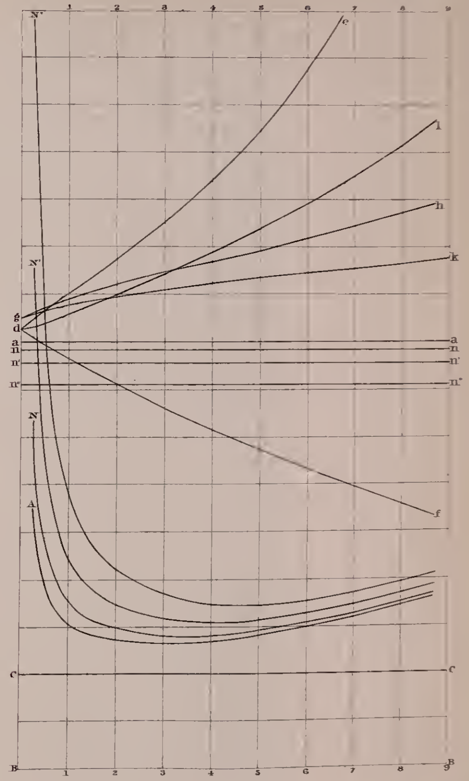
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DEPHOSPHORIZATION OF IRON.

By F. Gautier.

A paper read before the Society of Civil Engineers of Paris, July 4th, 1879.

Translated by CHAS. E. BILLIN.

Dephosphorization is a problem of great importance in metallurgy. In the proportion of *one per cent.* phosphorus renders iron easily fusible, a property precious in the foundry, without doubt, but unfortunately accompanied by a very great fragility. *One-half per cent.* renders the iron more malleable and easier to weld when hot, but the fibre is replaced by a flat grain without resistance.

In steel low in carbon, 0·1 *per cent.* renders rolling impossible, prevents tempering, and gives a brittle metal unfit for any use.

I will not enlarge upon these disadvantages of phosphorus; they are known to you all. It will be sufficient for me to recall them in passing.

Unfortunately, phosphorus is of very common occurrence in the ores of iron. The most abundant ores are the poorest in iron, and also contain the greatest per cent. of phosphorus. These ores are characterized generally by *one-half per cent. of phosphorus, accompanied by about thirty per cent. of iron.* Iron made from them contains 1·5 to 2·0 per cent. of phosphorus.

In the ore the phosphorus is generally in the state of phosphate of lime or alumina. These phosphates are not decomposable by heat, and are irreducible by carbon or carbonic oxide. In order to displace the phosphoric acid, the presence of silica is necessary. This forms an earthy silicate, and then permits the carbon, or carbonic oxide, to exercise its reducing action and to free the phosphorus.

In the blast furnace and in presence of an excess of iron, these reactions lead finally to the production of phosphuret of iron, which disseminates itself through the metal. When the phosphorus is in the state of metallic phosphate, its reduction takes place without the intervention of silica, and at a lower temperature.

It is thus that *all the phosphorus of the furnace burden, ore, flux and fuel concentrates itself in the pig metal,* and this is even more the case when the furnace is working very cold, for then traces of this dangerous metalloid are found in the slag.

It is easy to comprehend, in the presence of this fatal accumulation of phosphorus in the pig metal, which is the first material in the iron and steel industry, that attempts have been made to purify the ores.

I spoke to you, some years ago, of attempts at dephosphorization which I had witnessed in Bohemian works. At Kladno they sought to dissolve the phosphate of lime and of alumina of the ore by scouring with a solution of sulphurous acid. They only succeeded in a reduction of 30 per cent., and this at an expense of 30 francs ($6) per ton of metal. It was a cumbrous process, not practical, and has been almost forgotten.

What is to be done, then? Attack the pig metal direct.

To be better able to judge of the real progress, it will be well to review the different methods employed.

Dephosphorization in Puddling.—In the reverberatory furnace, on a cast iron bed-plate covered with oxide of iron, the metal is kept in a liquid state. The oxidizing action produced by the contact with the oxide of iron, by the free oxygen from the gases of the hearth, and by the air, which enters at the doors, is further facilitated by the energetic working of the metal, which renews the exposed surfaces. This constitutes the work of puddling.

The most oxidizable bodies, silicium and manganese, are the first to pass off in the slag. As to the phosphorus, the final elimination of which generally attains to 60 per cent., it is usually admitted that it is transformed in part into phosphate of iron, but above everything else its elimination is attributed to the *liquation.* When the metal clears itself of foreign elements that it contains it becomes less fusible, and passes into a solid state in the midst of liquid slag, which surrounds it. It is at this moment that occurs the greatest purification during the puddling.

The *liquation* certainly plays a very important *role,* but the single process of the fusion of the iron in contact with the oxide of iron of the bed of the furnace, constitutes a dephosphorization of 40 per cent. This is a point to which I wish to call your attention for a moment, because it throws a certain light on the processes which we will study together later.

We find in the scientific studies of M. Snelus, on Dank's Mechanical Puddling, the following results:

Brand		Pig metal	Melted Iron.	Puddled Iron.
Staffordshire (grey),	Carbon	2·74	2·55	trace
	Silicon	2·25	0·92	"
	Phosphorus	0·63	0·35	0·24
Cleveland (grey),	Carbon	3·18	2·83	trace
	Silicon	1·20	0·80	"
	Phosphorus	1·49	0·91	0·46
(white),	Carbon	2·30	1·30	trace
	Silicon	0·89	0·18	"
	Phosphorus	2·17	0·86	0·38

This is a fact which I have equally verified in melting some of the phosphoric iron of the Moselle on the bed of a furnace and then puddling it.

Pig metal, . . .	1·65 per cent.	of phosphorus.
Melted iron, . . .	0·90 "	"
Puddled iron, . .	0·64 "	"

The total dephosphorization is 61 per cent., of which 46 per cent. is due to the action of fusing it on the bed of the furnace with oxide of iron. Only 15 per cent., therefore, is due to further oxidation and to liquation.

Special Dephosphorization in Puddling with Manganiferous Iron.—When puddling has for its object the production of a specially pure iron, it is accomplished by adding manganese. This is a very recent industry, which had its origin in Belgium, whence it afterwards extended into Germany and a part of France.

To the iron containing phosphorus is added spiegeleisen in such quantities as to have in the mixture from 2 to 3 per cent. of manganese; then it is puddled at a high temperature. The presence of manganese retards the purification and increases the amount of necessary working. The number of charges, in a turn of twelve hours, with a furnace for two workers, falls from 8 or 9 to 4, and the product decreases from 1500 kilogrammes to 900. The waste or loss is not very great because it is hidden by a considerable consumption of scrap iron, which is used to maintain or keep up the furnace bed, but the dephosphorization is energetic and can attain to 97 per cent. With an iron containing 1·6 per cent. of phosphorus, which, without manganese would yield after puddling 0·6 to 0·7 per cent., there is often obtained an iron which contains only a half-thousandth of phosphorus, as shown in the following table :

	Pig Iron.	Melted Iron.	Puddled Iron.
Carbon,	3·5	3·3	0·15
Silicon,	1·1	0·3	trace
Manganese,	2·6	0·6	0·06
Phosphorus,	1·6	0·5	0·05

The simple fusion of the iron has led to a dephosphorization even greater than shown in preceding examples.

En résumé, this is a very satisfactory purification, but it is excessively expensive and can only lead to the satisfaction of very special needs.

The Heaton Process created some stir in England ten years ago, and has been the object of very complete and interesting studies on the part of M. Gruner.

Into a cylindrical vessel of sheet iron, lined with refractory earth, is poured the molten metal. The bottom of this vessel is a plate of cast iron, or, better still, a piece of sheet iron, 4 millimetres thick, which is pierced by holes and destined to be melted down by contact with the molten iron, which then tumbles into a sort of caldron containing nitrate of soda. This salt is decomposed instantly, and produces compounds of oxygen and nitrogen, which traverse the column of liquid metal, and make it undergo in a few moments of time an energetic purification. An iron with 1·5 per cent. of phosphorus gave a half solid product, still having 0·6 to 0·9 of phosphorus and 0·14 to 0·16 of silica. This was not cast iron, for the decarburation was considerable, and neither was it wrought iron nor steel. The waste was only 5 or 6 per cent., but the amount of nitrate used ought to be more than 10 per cent., in order to obtain good results. In short, the process was incomplete, expensive, and could only furnish the first material for the manufacture of steel in the Martin-Siemens furnace; therefore it was not used.

Here stops the account of means for dephosphorization placed at the disposal of metallurgists, until within the last few years.

The Bessemer Process gives no purification whatever, but on the contrary, a concentration of the phosphorus in proportion to the waste.

It is thus that with Cleveland iron, containing 1·46 per cent. of phosphorus, Mr. I. Lowthian Bell obtained steel with 1·62 per cent., and at the Essen Steel Works, with the same iron, was produced a steel containing 1·77 per cent.

In the *Martin-Siemens* process, which produces steel on the bed-plate of a reverberatory furnace by melting a mixture of cast iron and scrap, either wrought iron or steel, there is the same concentration of phosphorus.

Whence comes, then, this anomaly? The theory of dephosphorization is not yet complete, but we agree more or less in acknowledging that several conditions concur to produce purification.

1st. *Oxidizing action,* for transforming the phosphorus into phosphoric acid.

2d. *Basic slag,* in order to permit the absorption of silica, which is of necessity encountered in all metallurgical operations, and to facilitate the combination of the phosphoric acid produced.

3d. *Liquation,** or the separation of the solid product from the phosphoric slags which proceed from the refining and flow off in a liquid state.

Finally, *the temperature,* to which of late has been attributed a certain influence, either that its elevation decomposes the phosphates produced, or, rather, that the basic affinities of the silica are quickly excited and set the phosphates at liberty.

All these conditions certainly have not equal influences, but each seems to have its own.

In puddling we meet an energetic oxidizing action, produced as much by the action of the peroxide of iron which constitutes the furnace lining as by the peroxidized slag under the influence of free oxygen contained in the products of combustion. The air entering at the doors is another cause of oxidation which we must not forget. The *basic state* of the slag is not doubted, since the bed of the furnace is entirely covered with oxide of iron, and as the slag *en présence* contains commonly 10 to 12 per cent. of silica, and rarely more than 20 per cent. As to the *liquation,* it is characteristic of this operation; there has been, perhaps, an exaggerated importance attached to this portion of the process in explaining the elimination of phosphorus; some one has even gone so far as to say that wrought iron forming (or "coming to nature") in the midst of a phosphoric slag is like ice, free from salt, being formed by the freezing of sea water. *The temperature* in puddling is relatively low; moreover, it has been found in the treatment of certain iron, very high in phosphorus, that it was important, in order to obtain a good purification, not to have the heat too intense.

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* This portion of the puddling process is called by American puddlers "coming to nature." C. E. B.

We see, then, that in puddling, all the conditions more or less known as necessary to dephosphorization are to a great measure fulfilled, and make of this process an energetic method of purification.

In the Heaton process what do we find? The *oxidizing action*, although of short duration (it lasts only from 2 to 5 minutes), has here an intensity peculiar to this process; it is an explosive, instantaneous action, utilizing the oxygen as soon as it is free, or feebly combined with nitrogen in easily dissociable products. The *slag is basic*, for it contains a minimum of 30 per cent. of soda, which has powerful affinities, and 10 to 20 per cent. of oxide of iron; it also contains sometimes 54 per cent. of silica. The product was pasty and only half fluid; there was a kind of *liquation*, which did not show itself in any way except when the spongy metal, filled with slag, was reheated and hammered. Finally, the *temperature* is relatively low, and certainly would not permit the phosphate products being decomposed either by the heat alone or by the exaltation of the basic affinities of the silica. This is certainly a group of favorable conditions, which explain sufficiently the purifying character of this process.

It will not be the same if we consider the Bessemer operation. Although the oxidizing action is of an extraordinary intensity, the slags are very silicious, containing from 40 to 50 per cent. of silica, which is derived as much from the silica of the metal as from the lining, essentially silicious, of the converter. It is not necessary to speak of the liquation, since the product is extremely fluid, like the slag which covers it. As to the temperature, it is excessively high, and we can reasonably believe, as regards this portion of the process, that it is sufficient to prevent all stable combinations of the phosphoric acid with the slag.

These conditions, that we also find in the Martin-Siemens, with, however, a more feeble oxidizing action, certainly do not constitute a satisfactory *ensemble* when dephosphorization *alone is considered*, and we can scarcely be astonished that the purification amounts to nothing in either one or the other of these processes for the manufacture of steel.

One can even go further, and say that most prominent metallurgists had lost hope of applying to steel any method of dephosphorization.

In presence of these difficulties, that neither the chemist nor the empiricist seemed able to surmount, we had taken up with interest a solution which permitted leaving in the steel a proportion of phosphorus five or six times greater than what had been thought possible before this.

M. Euverte explained, some years ago, how, thanks to the employment of ferro-manganese, a reducing agent more concentrated and energetic than spiegel, the final oxidation of the metallic bath in the Bessemer and Martin-Siemens processes, could be raised without introducing into the steel so large a quantity of carbon. He showed, also, how the diminution of carbon permitted leaving in the steel three or four thousandths of phosphorus without injuring the product sufficiently to prevent its being used for rails. This was a vast field opened to the employment of iron rails, for their conversion in the Martin-Siemens furnace into steel rails of a good quality, containing phosphorus; but it was not the dephosphorization of impure pig metal.

The above has been the necessary preface to the important question which is the subject of this communication.

From this point the subject divides into two portions:

1st. Dephosphorizing operations, without the elimination of the carbon, or furnace purification (*mazéages epurateurs*).

2d. Manufacture of steel from phosphoric pig metal.

1st. Furnace Purification.

Mr. I. Lowthian Bell, whose numerous and interesting works on the blast furnace have given him a reputation of the first order, has obtained remarkable results in the dephosphorization of Clarence pig iron, of which the extreme limits of composition are as follows:

Carbon, ...	3·670 to 3·20
Silicon, ...	2·810 to 1·50
Sulphur, ...	0·102 to 0·02
Phosphorus, ...	1·930 to 1·08

This is iron made from Cleveland ores without mixing those of other origin.

We have seen that, in treating Cleveland iron containing 1·46 per cent. of phosphorus, by the Bessemer process, Mr. Bell obtained steel which contained 1·62 per cent., the lining of the converter being *gannister*, or nearly pure silica.

With the same lining and an addition of 30 per cent. of pure oxide of iron mixed with the melted slag, he did not obtain any better result. He had then an intense boiling, but no dephosphorization. Trying to account for his unsuccess, Mr. Bell attributed it to the imperfect contact of the metal with the oxide of iron, and made another attempt.

In the same converter he blew the metal beyond the ordinary stopping point in Bessemer operations, until 25 per cent. of the iron had been oxidized. He hoped that, owing to this, the oxyd of iron, in a nascent state, would act more energetically, and to obtain a more intimate contact with the metallic bath. The only result was an augmentation of 24·8 per cent. in the proportion of phosphorus, which was thus concentrated in the product in exact proportion to the loss.

Renouncing then the attempt to produce steel directly from phosphoric iron Mr. Bell turned to another side. The failure of the Bessemer process in these attempts seemed to him to be principally due to the elevation of the temperature, which led, without doubt to the decomposition of the phosphate of iron in proportion as it was produced.

At the Bowling furnace he treated a certain quantity of his iron and obtained the following results:

	Pig metal.	Refined pig.
Carbon,	3·12	2·50
Silicon,	2·80	0·12
Sulphur,	0·11	trace.
Phosphorus,	1·47	0·84

This was a dephosphorization of more than 40 per cent. In analyzing the phenomena, we find that this operation took place in a vessel with walls of cast iron, cooled by a current of water, and under the action of an oxidizing blast of low temperature. As the slag contained scarcely 25 to 30 per cent. of silica we could reasonably attribute to the oxide of iron, which it contained in large quantities, an important action in the dephosphorization.

In cooling slowly, some metal taken from one of the Clarence furnaces, in contact with melted oxide of iron, Mr. Bell obtained results analogous to those which were given for the experiment at the Bowling furnace.

	Pig metal.	Metal having passed over the oxide of iron.	Refined metal.
Carbon,	3·305	2·731	2·500
Silicon,	2·163	0·028	0·120
Sulphur,	0·102	0·056	trace.
Phosphorus,	1·515	0·838	0·840

Employing then the Godfrey and Howson mechanical puddler, which is composed of a sort of converter able to turn on itself or to incline at any angle, and which is heated by a jet of gas entering by the mouth, Mr. Bell made numerous experiments in treating Clarence iron. The lining was oxide of iron, of which the composition varied, so that the oxide melted or simply heated as added. Below are the results obtained:

	Pig metal.	Metal after treatment.
Phosphorus, . .	1.50	0·23
Silicon, . . .	2·06	0·10

The purification was very satisfactory, as may be seen; but everything depends on the temperature, and the feeble capacity of the vessel would be found to be the cause of projections which would condemn the apparatus.

For his last experiments Mr. Bell designed an oscillating furnace having the form of a cylinder four metres long and one metre in diameter. A longitudinal partition separated it into two parts, and served to insure the stirring up of the liquid metal, and its contact with the melted oxide of iron at each movement of the apparatus. In ten minutes a charge of 700 kilogrammes of metal was submitted to sixty or eighty oscillations. The operation was stopped when bubbles of carbonic oxide were seen traversing the liquid mass and coming to the surface, burning in the form of blue flames. As in preceding experiments, the nature of the oxide of iron was varied, and Mr. Bell succeeded, even with calcined Cleveland ores, in producing a remarkable dephosphorization. The waste was from 0· to 2·5 per cent.

Below are given, from information obtained from Mr. Bell, some of the results:

	Metal before treatment.	Metal after treatment.
Carbon, . .	3·5	3·25 to 2·75
Silicon, . . .	1·7	0·5 to 0·20
Phosphorus, . .	1·5	0·1 to 0·05

This is, without any doubt, a very good dephosphorization without notable decarburation; the product is purified metal that can be cast, in order to employ it afterwards in the manufacture of open hearth steel. This is what was done at the Woolwich Arsenal, and the truly remarkable products, which secured for Mr. Bell a high reward at the Universal Exposition of 1878, were obtained in this manner.

Without pretending to have completely solved the question of the most suitable apparatus, Mr. Bell stopped temporarily his interesting researches.

MM. Narjes and Bender, engineers of the steel works at Essen, have put in practice a *purifying furnace*, for which the patent was taken out by the firm of F. Krupp.

The pig iron is melted in a cupola, though it might be taken with advantage from the blast furnace direct. On the inclined bed of a revolving furnace analogous to Pernot's furnace, and heated by Siemen's system, is a lining of oxide of iron. We have not the details as to the agglomeration of this oxide of iron, but it is easy to imagine that it might be attained by working at a higher temperature than that at which later work is carried on. Moreover, there is formed a purifying bath, in melting, more or less completely, on this bed a certain quantity of iron ore which naturally contains an average amount of silica. This bath has a thickness of about 30 centimetres. The iron to be refined is slipped into the furnace, which is then turned, at first slowly, with a speed of only two revolutions per minute, which is afterwards increased to five; the movement is given by a six-horse power machine which, however, is found to be a little light for this work.

According to M. Wedding, Professor in the School of Mines, at Berlin, the operation never takes more than ten minutes for a charge of 4 tons of metal. As in the last experiments of Mr. Bell, the operation is stopped when a disengagement of the carbonic oxide is perceived. The amount of waste is variable. Generally slight, it is sometimes even nothing, owing to the reduction of a part of the oxide employed, under the action of the silicon, and perhaps of the phosphorus. By this process 80 tons can be treated every 24 hours, with a consumption of 7 to 8 tons of coal and 15 tons of ore. It is said that 8 to 10 francs (80c. to $1.00) is the entire cost of the operation, but this is not at all sure. As to the dephosphorization, it is from 75 to 80 per cent., and would be facilitated by the presence of a small amount of manganese.

	Carbon.		Phosphorus.	
Metal.	Before.	After.	Before.	After.
A	3·17	3·02	1·220	0·303
B	3·90	3·75	0·630	1·131
C	3·81	3·56	0·450	1·108

This industry, in the works of Essen, served only for the demonstration of the process or to experiment with pig iron which people wished to have treated. The Forge Company, of Dillingen, started this method of manufacture, at Hussigny, near Longwy, France, and built a blast furnace in such a position that the metal could be let directly into the purifying apparatus.

There is a certain analogy between the purifying processes of Mr. Bell and of Messrs. Narjes and Bender. Their common character is a marked dephosphorization without hastening decarburation. We have said nothing of the removal of silicon at Essen; it is evidently complete, and prevents later treatment of the metal by the Bessemer process.

These refined metals can be usefully employed in puddling, for the improvement of the puddled iron; or, if the proportion of phosphorus is sufficiently small, they can be used in the Martin-Siemens furnace for the manufacture of *phosphoric steel* rails.

Why is the operation stopped at the moment when decarburation commences? It appears to us that there are two reasons: the result obtained would not be perceptibly improved by prolonging the operation; the result would, perhaps, be in part destroyed by the reducing action of the carbonic oxide, as we will explain further on; besides, it would sensibly increase the expense in removing carbon which would have to be replaced. Moreover, the apparatus does not permit, on account of either the manner in which it is built or its temperature, the necessary conditions for the production of steel; we would obtain wrought iron.

2D. MANUFACTURE OF STEEL FROM PHOSPHORIC PIG METAL.

Thomas and Gilchrist Process.—Two young men, Mr. Sidney Thomas, chemist, studying metallurgy only as an amateur, and Mr. Percy Gilchrist, chemist of the Blaenoven Works, Wales, and a recent graduate of the School of Mines, London, associated themselves to try and find some method of dephosphorization in using the Bessemer process.

Starting with the idea that a basic lining was indispensable, they constructed a small converter, capable of treating only a few kilogrammes of metal. They lined it with lime cemented together with a silicate of soda, and obtained results which attracted the attention of Mr. Edward Martin, director of Blaenoven. He authorized them to construct a converter of the capacity of 200 kilogrammes, which they furnished with the same basic lining. To absorb the phosphoric acid produced and to preserve the lining from the destructive action of the silica formed by the oxidation of the silicon of the metal, they employed various basic additions, of which lime and oxide of iron were the elements. They attempted at the same time to push the operation beyond the point of decarburation, that is *to overblow*, and they thus obtained a remarkable dephosphorization.

These experiments were repeated at the Dowlais Works, with a full sized converter, capable of treating five to six tons of metal. The preceding results were confirmed, but some accidents occurring to the lining stopped their experiments; they were continued at the steel works of Bolckow Vaughan, at Eston, near Middlesborough (Cleveland).

Mr. Windsor-Richards, director of this establishment, with the co-operation of Messrs. Thomas and Gilchrist, imparted a strong impulse to these researches.

A lining of oxide of iron and additions of oxide of iron alone, without mixing any lime, did not succeed; the reactions were too rapid, and the operations rendered impossible by the spouting and boiling. They were therefore obliged to return to the earthy lining.

An attempt at the manufacture of bricks from dolomite showed all the difficulties of the problem. After pulverizing this material, working it up with water, moulding and baking it, there was a reduction of 33 per cent. in volume and a loss in weight of 45 per cent. Several accidents occurred: sometimes the unequal heating led to the twitching of the mass in baking and to numerous ruptures; sometimes, on account of insufficient heat, the bricks obtained decrepitated like lime upon exposure to the air; or, at other times, owing to an excess of heat, the bricks ran together and melted with the oven. They succeeded, however, in determining this first part of the problem. It seemed, moreover, that this question of lining had several satisfactory solutions.

Mr. Gilchrist recommends the following composition:

Silica, ...	10
Alumina and oxide of iron, . .	4 to 6
Magnesia, ...	30
Lime, ...	54 to 56

The bricks employed in the operations that we have studied at Eston had the following composition, which differs notably:

Silica,	9·50
Alumina,	10·00
Peroxide of iron,	4·46
Magnesia,	21·50
Lime,	50·25
Soda,	4·00

This is dolomite agglomerated with silicate of soda.

Finally, Mr. Riley makes his bricks as follows: He takes pulverized dolomite, which he mixes with petroleum or some analogous mineral oil, which gives the bricks the following composition:

Silica,	8·85
Alumina and oxide of iron,	4·00
Magnesia,	35·00
Lime,	51·00

A filling clay can also be made with this material in mixing it with the same liquid; it is said this would give very good results.

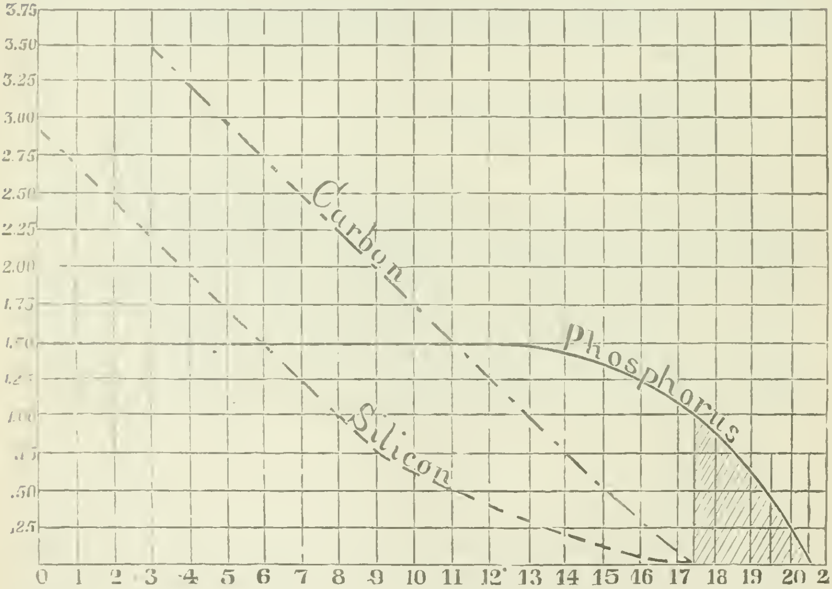
Mr. Richards described, at the meeting of the Iron and Steel Institute of London, an operation performed at Eston with Cleveland iron, of which the different phases had been studied chemically. The operation was performed on 6000 kilogrammes in a converter capable of containing eight tons. The pig iron had the following composition:

Silicon,	3·0
Carbon,	3·5
Phosphorus,	1·5

Immediately after the introduction of the pig metal there was added 500 kilogrammes of lime, and, six minutes later, another addition of 400 kilogrammes of lime and 300 of oxide of iron; this made a total of 1200 kilogrammes, or 20 per cent. of cold material.

The operation occupied 17 minutes, 9 for the first period and 8 for the second. A series of samples were taken and submitted to chemical analysis, resulting in a very interesting study of the changes of composition which occur during the refining. Mr. Richards constructed a diagram, the abscissas of which are the fractions of time occupied by the operation, and the ordinates are the different quantities of the elements contained in the metal.

It is seen that the phosphorus commences to disappear only after the carbon is reduced to 1 per cent. and the silica to 0·3 per cent. The shaded portion of the diagram indicates the *overblowing;* this is the blowing which takes place after the total decarburation characterized by the fading away of the rays of the spectrum. It is a period during which oxide of iron is produced abundantly, and it is seen that it is also the time when the phosphorus is rapidly eliminated. In the case represented by the diagram the overblowing lasted three minutes, and in this short space of time two-thirds of the phosphorus was oxidized, whereas the other third had demanded twice this time to be scorified.



Mr. Richards vouched for the fact that the metal in which the phosphorus had been reduced to less than a thousandth had a tensile strength of 70 kilogrammes per square millimetre, with an elongation of 25 per cent. in a length of 200 millimetres.

As to the waste, it oscillated between 18 and 20 per cent., varying with the dephosphorization which was attempted. When it was desired to have less than *a thousandth* of phosphorus in the metal, the waste amounted to 25 per cent. Ordinary pig metal, that of Cumberland for example, would give only 15 per cent.

The following description is of the two operations performed at Eston, May 13th, 1870, before the members of the Iron and Steel Institute.

First Operation.—They employed an 8-ton converter, lined with basic bricks, the composition of which has already been given; it was dolomite agglomerated with silicate of soda, a lining not very durable, perhaps, but which was preferable for the demonstration of the process.

Five tons and eight hundredweight of Cleveland iron was melted in a cupola, all the blast furnaces being stopped on account of a strike among the Durham miners. This iron had the following composition:

Silicon,	3·030
Carbon,	3·200
Sulphur,	0·030
Phosphorus,	1·800
Manganese,	0·450

Immediately after the introduction of the metal, there was thrown in from a barrow 1200 kilogrammes of a greyish material, in pieces about twice the size of a nut; it was the result of the roasting of a mixture of carbonate of lime and "blue billy." *

This material was cold, and had the following composition:

Silica,	1·00
Lime,	60·00
Peroxide of iron,	31·89
Carbonic acid,	6·40

This could not be prepared many days in advance, as it decrepitated by absorbing moisture from the atmosphere.

The operation, followed with the spectroscope, gave a period of 4 minutes and a second of 9½. After the falling of the flame there commenced an "overblowing" of nearly 3 minutes, and distributed about as follows:

1st. Overblowing of a minute and three-quarters; the converter was then turned down, and a specimen of the metal taken with a sort of ladle; this was cooled in a small ingot-mould, and then hammered into the form of a disk, one centimetre in thickness; it was recooled and broken under the stamper. The grain is coarse, flat, and bright, as that of very phosphoric iron. We will give later the amount of phosphorus contained (A^1).

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* Blue Billy is obtained in the treatment of calcined pyrites from which the copper has been extracted by the Henderson process.

2d. Overblowing of 45 seconds, and sample taken (A^2).

3d. Overblowing of 20 seconds, and sample taken (A^3).

All these successive attempts had prolonged the operation to about twenty minutes.

Next they proceeded to add 10 per cent. of spiegel, melted in the cupola and having the following composition:

Manganese,	17·000
Phosphorus,	0·163

This was introduced by degrees, on account of the violent reaction of the carbon of the spiegel with the oxide of iron in solution in the metal. It caused a greatly developed flame, and there is an overflow of a part of the slag.

	Phosphorus.
Pig metal,	1·800
A^1,	0·597
A^2,	0·360
A^3,	0·140
After spiegel,	0·235

This metal when rolled had the following composition:

Carbon,	0·330
Manganese,	0·213
Phosphorus,	0·235
Sulphur,	0·073

The ingots weighed from 600 to 700 kilogrammes. There were two roughed down, which behaved very well, and were rolled into small rails, having the weight of 20 kilogrammes per metre.

Second Operation.—The second operation was easy, compared with the first.

The charge of pig metal taken from a cupola was 6000 kilogrammes, and the addition of cold basic materials was 1200 kilogrammes. Observation with the spectroscope gave 7½ minutes for the first period, and as much more for the second. There were neither boiling nor violent projections, as in the first charge, due no doubt to the great capacity of the converter.

The overblowing, in which is included the taking of samples and all time lost, lasted nearly 20 minutes. Specimens B^1, B^2, etc., were taken, as in the first operation, and below are given the results of their analyses:

Overblowing.		Phosphorus.
Pig metal,		1·800
1 minute 30 seconds,	B^1,	0·830
30 "	B^2,	0·458
15 "	B^3,	0·334
15 "	B^4,	0·210
10 "	B^5,	0·140
After spiegel,		0·223

The addition of spiegel was 10 per cent. The reaction which followed was tumultuous, and the operation seemed to give a cold metal. The casting ladle became obstructed, and it was necessary to keep the tap-hole open with an iron rod. An ingot "scattered" some minutes after, which is characteristic of the overblown metal.

As to the rolled metal, it gave

Carbon,	0·171
Manganese,	0·160
Phosphorus,	0·223
Sulphur,	0·037
Silicon,	trace.

Two ingots were "roughed down"; one presented a great crack, which enlarged in finishing, but as the rail was 32 metres long, it could be cut up into useful pieces. After blooming, the other ingot showed numerous small cracks, indicating a red-short metal.

After these two operations, the condition of the lining seemed good; there could be noticed some cross-cracks, but the intensity of the radiation did not permit one to decide whether this was not the effect of the joints of the bricks. The bottom, where the tuyeres were replaced by holes cut in the lining, presented no cavities. It seemed but slightly worn, to judge of it by its flattening. The slag accompanying the metal of the last operation had about the following composition:

Silica,	21·50
Lime,	36·00
Magnesia,	4·94
Alumina,	1·30
Peroxide of iron,	6·09
Protoxide of iron,	9·94
Protoxide of manganese,	7·50
Phosphoric acid,	9·70

If this slag was homogenous, a simple calculation would show that the wear and tear of the lining had been 700 kilogrammes, because this slag contained nearly 5 per cent. of magnesia, which could only come from the lining, as there was no magnesium in the metal, and as the addition of 1200 kilogrammes of lime and oxide of iron contained only traces of magnesia. However this may be, there was a certain wear which is incontestable, and which only a successive series of operations could measure correctly.

If we consider the process of Messrs. Thomas and Gilchrist in its entirety, we see that from the first it is very satisfactory. What more simple in reality than to resolve the problem of dephosphorization, *without special apparatus, into absorbing the phosphorus by a basic addition destined to protect the lining, and to finish the operation in prolonging the blowing.*

If we study, on the contrary, the operations which we have just described, and compare them with the treatment of ordinary pure metal, we find;

That the capacity of the converters is utilized only in part, which is a cause of cooling, and a greater expense in erecting.

That by the repeated taking of samples, the operations are prolonged to at least double their length, which is a diminution of the production and a new cause of cooling.

That the waste is notably augmented.

That there is no character which announces the end of the dephosphorization, which necessitates numerous trials.

It seems difficult to obtain by this method a metal relatively carburetted.

Finally, *notwithstanding the large proportion of manganese introduced, the metal has a tendency to remain red-short, and consequently to roll irregularly.*

A last character, to which we will return later, is the *rephosphorization of the metal after the addition of the spiegel.* The amount of phosphorus in the metal, after having been reduced to 0·140, rises again to 0·235 and 0·223. This is a very curious phenomenon that the English metallurgists explained by a reducing action of the manganese exerted on the phosphate products, and of which the slag contained quite a large proportion. If the phosphorus is in the slag, in the state of phosphate of lime, of manganese, or of alumina, no such reaction seems possible. If the phosphorus is in the state of phosphate of iron, it would be necessary that a phosphuret of iron or of manganese be produced, going over again into the metal, which also seems to us improbable.

Ponsard Furnace-Converter.—This is an apparatus which partakes of the characteristics of both the Bessemer converter and the Martin-Siemens furnace. In a certain position of the movable bed-plate there can be placed tuyeres which blow air into the metallic bath.

Attempts at dephosphorization have been made with this apparatus at Thy-le-Chateau, near Charleroi. With a basic lining, analogous to that of Messrs. Thomas and Gilchrist, they would have been able to have produced steel from very phosphoric iron. But these trials were not very conclusive, the heat having been insufficient. New experiments ought to be undertaken before long at Creil. They should employ simultaneously the Ponsard recuperator and the Siemens regenerator, which alone can lead to a very instructive and interesting comparison.

It remains for us now to present some general observations on the chemical phenomena which are met in the several methods of dephosphorization of which we have spoken.

There is one fact which strikes us first. It is that, in furnace purifications, the dephosphorization takes place without any important elimination of the carbon; with the Bessemer process, on the contrary, there is no notable dephosphorization until after the carbon has been much reduced, and the dephosphorization is completed only after total decarburation.

How reconcile these two contradictory phenomena?

The following is the explanation given by M. Pourcel, in charge of the steel works at Terre-Noire, in a communication which he made June 7th, 1879, to the Society of Mineral Industries of Saint Etienne.

The carbonic oxide exerts an energetic reducing action on the phosphate of iron. Under its action there is formed phosphuret of iron, which dissolves in the metal or steel surrounding it. This reducing action ought, without any doubt, to increase with the temperature.

In the purifying processes of Mr. Bell and of Messrs. Narjes and Bender the oxidizing action of the peroxide of iron exerts itself on the silicon and phosphorus from the very first. There is formed silica and phosphoric acid, which combine with the oxides of iron present. As there is little or no carbon burnt, there is no carbonic oxide produced; the phosphate of iron formed has not then an opportunity to be reduced, since the operation is stopped when the disengagement of gas commences. It is the presence of the silicon which prevents the combustion of the carbon, the same as in the Bessemer process. Further, as long as there is silicon present the carbonic oxide cannot remain in solution in the metal; it is decomposed, as shown in the theory of the manufacture of blister-steel.

One can even go further, and say that if there had not been any silicon present, these purifying processes could not have been operated unless a strong proportion of manganese protected the carbon against oxidation.

In the Thomas and Gilchrist process, on the contrary, we see the dephosphorization commences only when the proportion of carbon is below one per cent., and is not finished until after total decarburation. The oxide of iron produced then exerts itself exclusively on the phosphorus without being influenced by the reducing action of the carbonic oxide.

In this process what then is the effect of the basic lining and the additions of lime mixed with oxide of iron? The English metallurgists pretend that they are destined to saturate the silica produced and to permit the production of an earthy phosphate (lime, alumina, or manganese). They affirm, then, that the phosphorus is not in the slag in the state of phosphate of iron. The grounds on which they base their conclusions are the following:

The hydrosulphate of ammonia, while cold, transforms the phosphate of iron into sulphuret of iron and phosphate of ammonia. The chloride of sodium, when hot, transforms the phosphate of iron into chloride of iron and phosphate of soda. They have not succeeded in producing any of these reactions with the slags of their operations; but with weak acids they have been able to dissolve the phosphate of lime.

Is this method of reasoning, which takes no account of the disturbing action of the silica, unassailable? Are we not in presence of a silico-phosphate of iron, which resists the first reagents and succumbs to the more energetic action of acids?

If, on the contrary, we consider the decided development of carbonic oxide after the addition of the spiegel, and which does not appear at the mouth of the converter until after having passed through this thick bed of slag, containing, as we have seen, nearly ten per cent. of phosphoric acid, have we not there an energetic reducing agent which ought to play an important part? It is certainly this carbonic oxide which makes the phosphorus, removed from the slag, pass back into the metal. But this carbonic oxide, as we said in commencing, exerts no action on the phosphates of lime, of alumina or of magnesia; it is then the phosphate of iron which it reduces.

The phenomena is perhaps complex. It is possible that earthy phosphates are formed at the commencement of the operation, but it seems difficult to admit that, in the overblowing, the oxide of iron in the nascent state does not combine more or less with the phosphoric acid produced.

Monsieur Pourcel, in trying to connect all these methods of purification, could not see why, during the first period of the Thomas and Gilchrist process, the phosphorus should not be eliminated just the same as in the process of Mr. Bell and of Messrs. Narjes and Bender. It seemed to him that the phosphorus curve ought to sink toward the axis of abscissas during the combustion of the silicon, in order to rise afterwards during the combustion of the carbon, on account of the reducing effect of the carbonic oxide.

This manner of reasoning seems very logical, and would merit being verified by a special experiment, which would well repay such trouble.

There is, nevertheless, a certain difference between the purifying processes of which we have spoken and the first period of the Thomas and Gilchrist process. In the first case we have an oxidizing action, which is perhaps more energetic on account of the presence in excess of peroxide of iron, whereas in the Bessemer process the oxygen blast exerts itself on the silicon, perhaps, before acting on the phosphorus. The straight line of the phosphorus, in the diagram of Mr. Richards, is not a proof that dephosphorization has not taken place from the commencement; indeed, it would have been possible to have made only a quantitative analysis after the first period, when all the phosphorus oxidized would have been reduced, and to have concluded from this the absence of dephosphorization. The straight line of the carbon is quite hypothetical; that of phosphorus is perhaps as much so. It is, indeed, impossible that the proportion of carbon should remain constant, and this for two reasons: 1st. As there is elimination of silicon and a certain production of oxide of iron, the mass treated has diminished, the per cent. of carbon ought, then, to be augmented. 2d. The first period of all Bessemer operations is accompanied by reddish sparks, which are more or less abundant, but which are probably graphite partially burnt. But, after all, two analyses of Bessemer operations performed in Germany prove this augmentation of the carbon: according to Kessler, after 4 minutes the carbon passes in one operation from 3·58 to 3·79, and in another from 3·03 to 3·17.

To conclude, we say, 1st. *That the dephosphorization of pig iron by a purifying process in a furnace seems to us practically demonstrated.*

2d. *That with the Bessemer process the manufacture of steel from very phosphoric pig iron is a fact perfectly established and complete from a scientific point of view.*

There remain practical difficulties, that the authors of the process recognize themselves, and they seek to conquer them by continuing their experiments; but the moment does not seem to be very distant when all which still embarrasses the process will be completely resolved.

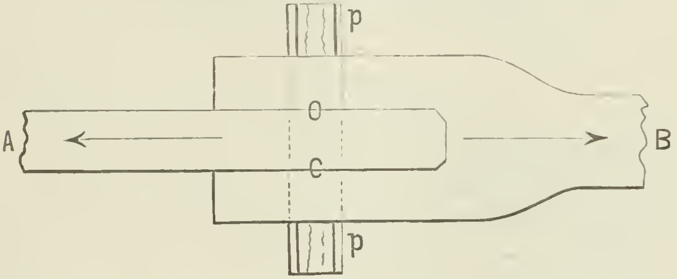
Nutritious Ferns.—The dwellers on the argillaceous mountains of Japan derive most of their food from a variety of ferns, which they call *warabi.* In spring they eat the young leaves; later in the season they feed on the starch which they extract from the roots. In extracting the starch, the roots are carefully washed in order to remove all dirt, then crushed by mallets, and the pulp stirred in reservoirs of water. The water is then drawn into other reservoirs to settle, depositing about 15 pounds of starch for every 100 pounds of roots. In order to secure the reproduction of the ferns, the natives often burn the herbage and brush-wood that spring up under the shade of the oaks and chestnuts. Vast tracts have been devastated by this deplorable practice.—*Les Mondes.* C.

Hunting by Electricity.—A new application of the Ruhmkorff coil has been made in the neighborhood of Marseilles. Instead of using bird-lime on trees which are frequented by birds of passage, a copper wire is wound around the trunk and a decoy attached to a neighboring staff. When a numerous flock has been attracted by the decoy, a shock is sent by the commutator, and they are more surely stunned than by a rifle. Experiments of a similar kind have also been made by M. Dalmas upon the vines at his country-seat, and powerful shocks are said to have destroyed the parasites together with their eggs. If this statement is confirmed, the ingenious inventor may reasonably expect the prize of 100,000 francs, which has been offered for the destruction of the phylloxera.—*Les Mondes.* C.

SHEARING STRENGTHS OF SOME AMERICAN WOODS.

By John C. Trautwine, C.E.

Notwithstanding the common use of wood for pins, or treenails, no experiments that I know of, except one or two isolated ones, and they imperfect, have been tried for determining the extent of its reliability for this purpose. With a view to supplying this deficiency in some measure, I have recently tested several of our American woods, in the shape of cylindrical pins ·64 of an inch (or full $\frac{5}{8}$ inch) in diameter. I used one of Messrs. Riehlé's well-known and accurate testing machines, in connection with an iron holder, shown in the figure, and through a cylindrical hole in which the closely fitting wooden pin, *pp*, to be tested was placed. The two parts *A* and *B* of this holder being then pulled in opposite directions, it is plain that the pin can yield only by direct shearing at *O* and *C*.



Two specimens of each were tried. Where their difference did not exceed 10 per cent., the mean is given. Greater differences must of course be of frequent occurrence, even in good sound specimens. All the specimens were fairly seasoned and without defects. The central pieces sheared off were $\frac{5}{8}$ inch long; The single circular area of each pin was ·322 of a square inch; and that of the two areas that were sheared at once ·644 of a square inch; and since $·644 \times 1·55 = 1$ square inch, it follows that if the results in the table be divided by 1·55, the quotient will be the actual double-shearing strength found for each pin of full $\frac{5}{8}$ inch diameter.

The following table gives the results in pounds per square inch of total sheared area:

	Pounds per sq. inch.		Pounds per sq. inch.
Ash,	6280	Locust,	7176
Beech,	5223	Maple,	6355
Birch,	5595	Oak, white,	4425
Cedar, white,	1372 to 1519	" live,	8480
" Central America,	3410	Pine, white,	2480
Cherry,	2945	" yellow, northern,	4340
Chestnut,	1535	" " southern	5735
Dogwood,	6510	" " very resinous,	5053
Ebony,	7750	Poplar,	4418
Gum,	5890	Spruce,	3255
Hemlock,	2750	Walnut, black,	4728
Hickory,	6045 to 7285	" common,	2830

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE STEAM INJECTOR AND EJECTOR OF J. H. IRWIN.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, November 15th, 1879.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination the Steam Injector and Ejector of J. H. Irwin, report that they have concluded the duty imposed upon them, and submit the following as the result of that investigation:

The experiments were conducted at the country place of Mr. Irwin, situated at Morton, about nine miles out on the West Chester and Philadelphia Railroad, where were found all the facilities needed for such an undertaking, there being an experimental machine shop, where the instruments experimented with were made, fitted up with all the appliances required, and workmen who understood the proper fitting up of the proper instruments and their connections.

The experiments occupied the committee five days' close application of about seven hours each, beside which one of the committee was occupied an additional week in preparing and arranging for the experiments.

Manner of Conducting the Experiments.

The water supply for the injectors was received in a large circular wooden tank, capable of holding 400 gallons, mounted on a large platform scale, having the capacity to weigh 6000 lbs. The delivered water from the injector was conducted, by wrought iron pipe, into another tank, situated on a similar platform scale. A chemical thermometer, Fahrenheit's scale, was kept immersed in the feed water tank for the purpose of observation; the delivered water was tested, as it left the injector, and as close to it as practicable, by a similar thermometer, fitted into an ordinary *tee* steam fitting by passing through a cork, the bulb of the instrument protruding into the current fluid.

A steam pressure gauge was arranged on the steam supply pipe, close to the injector, and a water pressure gauge between the thermometer *tee* and the injector, with a globe valve just beyond the gauge, to throttle the water discharge and regulate the delivery pressure, which in the first series of these experiments was adjusted to equal the pressure of the steam, in effect the same as forcing the water into the boiler; the gauges used were of Schaeffer and Budenberg's make, and were tested and adjusted especially for these experiments.

To test the injector under different lifts, a scaffold was erected just outside the boiler room, with stagings at two different heights; and in order to economize time and lessen the liability to error from leaky joints, in re-arranging the position of *a single* instrument, three injectors, of similar pattern, were taken at random from a lot, and erected permanently in the three several positions of altitude, all of which, however, gave a further range of lift as the water was lowered in the feed tank.

A Wiegand Boiler was used to furnish steam, having 9·625 square feet of grate surface, and to record the pressure of the steam was used an excellent mercury gauge made by David Lithgow, of Philadelphia.

A steam valve was fitted to the steam pipe outside, close to the injector, for the purpose of regulating the amount of steam admitted to the instrument, but was not used, except wide open, in the first series of experiments, the indications all being taken from the mercury gauge attached to the boiler: across the face of which was arranged a metal slide, which was set in a line with the pressure required, and the engineer kept the mercury *on the line of sight* by opening, closing and regulating the draft by the furnace door, throughout the several experiments in an admirable manner, and practically without any sensible variation in the pressure of the steam.

MANNER OF RECORDING THE EXPERIMENTS.

The manipulation of the injectors was done by the inventor, Mr. Irwin; the members of the committee had, individually, a separate duty assigned. One was stationed at the feed water scales, another at the delivered water scales; one observed the temperature of the feed water and took the height of the lift immediately preceding and at the close of each experiment; another took the temperature of the delivered water and noted the steam and water pressures, while duplicate records were kept by two different individuals, as a check upon each other.

Each experiment was started by the operator on the injector starting the instrument and adjusting it in proper running order for the work to be performed. When brought to this condition the word *now* was given, at which moment the weights on the two scales were taken, and the readings of the different gauges, thermometers and instruments of measurement were noted, and the experiment proceeded, for generally fifteen minutes. When the time was up by the watch the word *now* was again repeated, when instantly the weights and readings of the several instruments were again taken, reduced to the mean, and called off for record, warning being invariably given just before beginning and ending of each experiment. In this way there was no confusion, the duty of each was simple, and the posting perfect, while the manner of arriving at the results is eminently practical. Taking the first experiment as an exponent of them all, we find that 471·5 lbs. of water had been taken from the feed water tank, and 492 lbs. had been discharged into the delivery water tank, in fifteen minutes, it is obvious the difference, 20·5 lbs., must be the weight of steam used in effecting the trnsfer. In this way there are no doubtful calculations to be performed; not only has the water passed through the instrument been weighed, but the amount of steam used to perform the work has been accurately weighed and ascertained; the subsequent calculations made, and recorded in the appended tabular list of these experiments, are of a very simple nature, although requiring a considerable amount of arithmetical calculation. Each one furnishes the evidence to detect any error which may have crept in during the taking of any individual experiment, for if the units of heat in the feed water lifted per pound of steam at any given pressure be taken from the total units of heat found in the water delivered, the difference would show the units of heat pertaining to that steam, and the difference between the latter quantity and the theoretical heat in one pound of steam at the given pressure, taken from Regnault's tables, furnishes the error of the experiment, under the supposition that dry, saturated steam was used and losses from radiation, &c., omitted.

This check, showing the error of each experiment, is shown in columns 16, 17, 18, 19 and 20 of the first series of experiments.

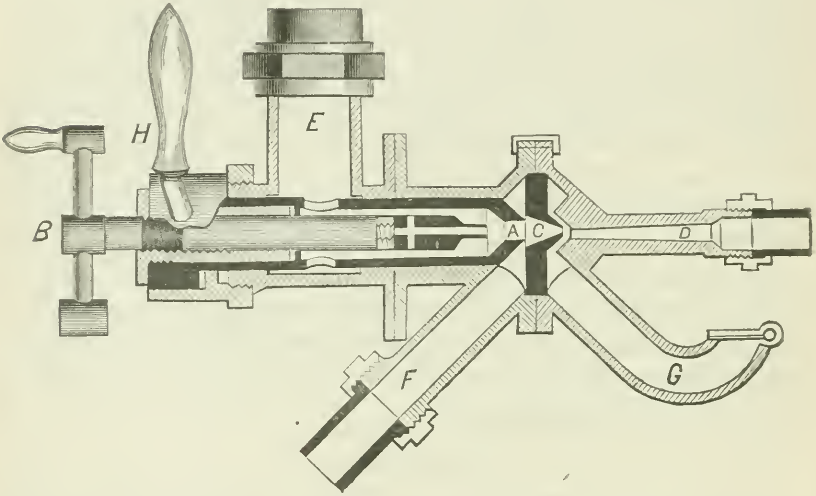
The fact, on the one hand, of the Wiegand boiler permitting the products of combustion to circulate around the steam drum, en route to the chimney, and thereby superheating the steam to a greater or less extent, and, on the other hand, that the steam on leaving the boiler passed through upwards of 30 feet of uncovered piping exposed to the outside air, renders some method of check necessary, not alone for these reasons, but also because of the unavoidable small errors in the several instruments used and the possible errors of the observers.

The scales used in these experiments were furnished by the courtesy of the Messrs. Riehlé Bros. They were of a superior class, and were accurately adjusted after erection.

THE INJECTOR,

As made in accordance with the laws laid down by Mr. Irwin, is of a general nature. The whole of the tabulated experiments shown in series 1, 2 and 3, ranging from where 105 pounds of steam pressure above the atmosphere was used down to 15 inches of vacuum, with the instrument still working, and where an augmented pressure of 330 pounds was obtained by 90 pounds of steam down to 10 inches of vacuum, where an augmented pressure of 10 pounds was gained; where 1 pound of steam forced against a pressure of 25 pounds, and 1 pound of vacuum against 15 pounds, including the hot water experiments, running up to where feed water of 122 degrees Fahr. was lifted 19 inches and forced by 30 pounds steam against an equally resisting pressure, and also where the water was lifted 21 feet with 40 pounds of steam against 60 pounds pressure, were performed *by the same instrument*, without a particle of change or alteration. In all these varied tests the instrument generally responded promptly, and ran through the allotted time, usually 15 minutes, without readjustment, and it was remarkable to observe how stationary all the gauges and thermometers remained, having once settled down to the work before them.

The law governing the economical action of injectors, as enunciated by Mr. Irwin, may be briefly stated to require the employment of certain angles and set dimensions of the interior working parts, which have been arrived at after a series of numberless experiments extending over a period of 6 years, of which the following are the most important :



A is the steam jet which is adjusted by means of the screw spindle and crank *B* ; this spindle contains a small starting jet

C is the combining cone in which the steam is condensed, and the issuing stream of water is received by the receiving tube *D*.

E is the steam supply pipe ; *F* the water supply pipe, and *G* the overflow.

The supply of water is regulated by means of the oblique slot and handle *H*.

Taking the lesser diameter of the combining cone as the standard of measurement of the instrument, which call . . 1
The larger diameter and length of combining cone, . . = 4
The diameter and length of jet opening in steam cone, . = 2
Smaller diameter of receiving cone, ... = 1
Larger " " " . . . . . = 2
Length " " . . . . . = 16
Diameter of starting steam jet, ... =0·5

There are also some other determined dimensions of universal application, a full explanation of which will be gathered from a perusal of the patents appended. One peculiarity may be mentioned. The water supply pipe and overflow are set at an angle of 45° to the axis of the instrument, which, it is claimed, materially increases the power of augmentation. Permitting the free entrance of the atmospheric air at and through the overflow, it is also maintained, gives a clear gain to the extent of one atmosphere in the same direction. This could be practically tested by placing the thumb over the orifice of the overflow, when the index of the pressure gauge would immediately fall back about 15 pounds, and advance again to the same extent by the removal of the obstruction. A way of proving the correctness of this assumption was to turn on steam enough to work the injector against any determined pressure when the overflow was closed, then by opening it a certain amount of steam could be shut off, producing the same pressure on the gauge. The steam so shut off was undoubtedly saved (see experiment A).

The dimensions of the instruments experimented with were:

Lesser diameter of combining cone and receiving cone,	$\frac{3}{16}$	inch
Diameter and length of jet orifice in steam cone,	$\frac{3}{8}$	“
Diameter of starting steam jet,	$\frac{3}{32}$	“

The other dimensions may be ascertained by recurring to the proportional dimensions above laid down.

The Result of the Experiments

Would lead to the conclusion that the information gained in regard to this injector is highly important in the cause of science, and that Mr. Irwin has contributed a valuable improvement in the manner of constructing injectors, increasing their power of augmentation to above twice that of the pressure of steam used for practical working without waste, and about four times with waste at the overflow, as will be seen by taking the average of the experiments shown in the 2d Series, which seem to carry out a general law, that *the lower the steam employed, the higher could the proportional augmentation of pressure be carried.*

In the first series of experiments, column 20 shows the percentage of error of each experiment. The method of checking the experiments can be shown algebraically as follows:

Let $R =$ the total heat of 1 pound of steam for the observed pressure, taken from Regnault's tables;

$D =$ the specific heat of the delivered water for the observed temperature;

$X =$ the weight of feed water delivered per pound of steam;

$F =$ the specific heat of the feed water for its observed temperature;

And $E =$ the error of the experiment.

Then, if we neglect the losses of heat due to radiation, and the small amount of work done in lifting the water to the injector, and consider that the friction of the water in forcing its way through the throttle valve converts the work done there into heat,

we have $$(1 + X)\,D - XF = R + E,$$

or, $$E = (1 + X)\,D - XF - R = D - R + (D - F)\,X.$$

If, further, we assume the error to be equal to zero, we have from the preceding equation $X = \frac{R - D}{D - F}$, which gives us a means of determining the weight of water fed per pound of steam with sufficient accuracy, when the three terms:

1. The steam pressure; 2. the temperature of the feed water; 3. the temperature of the delivered water, are known.

Taking for example experiment 3 of the First Series, we have

$$R = 1165{\cdot}6 \text{ heat units.}$$
$$D = 110{\cdot}267.$$
$$F = 30{\cdot}5.$$

$$X = \frac{R - D}{D - F} = \frac{1165\ 6 - 110.267}{110\ 3 - 30{\cdot}5} = \frac{1055{\cdot}3}{79{\cdot}8} = 13{\cdot}23 \text{ pounds,}$$

a quantity slightly less than the observed result, but only noticeably less because the experiment shows an error in excess.

The percentage of error is found by dividing the ascertained error (E) by the total quantity of heat in one pound of steam plus the heat of the delivered feed water $= [(1 + X)\,D]$.

The horse power of this injector can be determined with sufficient approximation from column 14, First Series, one pound of water per minute being, with sufficient margin in excess, the supply of water required per horse power.

The range of the injector is shown in a few cases in column 15, First Series, and is a criterion of its adaptability to the varying supply often demanded of an injector.

The committee were limited to 105 pounds steam pressure, as the boiler was not in a condition to use anything higher.

EXPERIMENT *A*.

Steam Press.	Water Press.	Temp. Delivery.	
90	93	138°	Overflow open.
90	83	136°	Overflow shut.

Opening the overflow again, the pressure rose to 93 pounds. Some steam was then shut off, reducing the water pressure to 83 pounds, the same as indicated with the overflow shut, when the temperature of the delivered water fell to 127°. This experiment was several times repeated, with the same general result. The experiments upon high temperatures of feed water not presenting as high a range as in the case of other injectors, certain alterations in the interior angles of the instrument were made, increasing the diameter and length of the combining and receiving cones, doubling their proportions, with an advantage in point of taking hotter water to the detriment of the other characteristics of the instrument, as will be seen by the following:

EXPERIMENT *B*.

Steam.	Temp.	Head.	
80	120°	13 inches	Water forced into boiler.
85	134°	10 "	There being a slight overflow.
95	144°	7 "	

The temperature of the feed water was now run down to 74°, in order to test the power of augmentation, resulting as follows:

EXPERIMENT *C*.

The instrument would just take water at .	35 pounds.
Commenced to overflow at . .	70 "
Broke at	75 "
With steam at . . .	90 "
Overflow at	125 "
Broke at . . .	150 "

The duty of the injector, though comparatively unimportant, has been computed, and is shown in columns 21, 22 and 23, First Series. Column 21 contains the head, and consists of the lift of the injector plus the resisting pressure of the water in pounds multiplied by 2·3 feet

Column 22 contains the duty per pound of steam.

Letting $h =$ the head in feet, computed as above, we have

$$h \times (1 + X) = \text{duty per pound of steam.}$$

Column 23 contains the duty, as ordinarily expressed, for pumping engines per 100 pounds of coal, estimated as capable of making 900 pounds of steam, upon the basis of an evaporation of 9 pounds of water per pound of coal.

All of which is respectfully submitted.

Washington Jones,
W. Barnet Le Van,
Tinius Olsen,
William M. Henderson,
Wm. D. Marks, *Chairman.*

Approved:
J. B. Burleigh, *Chairman pro tem.*
January 7th, 1880.

Experiments upon Human Heat.—Hirn has supplemented his brilliant thermo-dynamic experiments by an application of his method to the human organism, in order to ascertain its mechanical equivalent. He finds that in the normal condition, while the heat of the body is increasing or decreasing, every 425 kilogrammetres (3074·084 foot-pounds) of work costs or brings to the organism a unit of heat. By comparing the heat which really appears or disappears with that which ought to appear or disappear, we can study what is going on in our bodies, and how they are modified by the conditions in which they are placed. The laws of mechanical physics may thus teach us how and how much our organism differs from an ordinary machine.—*Comptes Rendus.* C.

Prediction of Harvests.—Hervé Mangon has examined the climatological conditions of the years from 1869 to 1879, in Normandy, and their influence upon the ripening of the crops. He gives three tables of the amount of heat received by different grains between planting and harvesting, and draws two important practical conclusions: 1. In a mild and regular climate it is generally desirable to sow the crops early in the fall. 2. By observing each year the amount of heat received subsequently to planting, and by consulting properly prepared tables, it is possible to calculate a month or six weeks in advance the time of harvest. In his own tables he fixed upon 6°C. (42·8°F.) as the growing limit, and recorded the number of degrees at each observation above that limit.—*Comptes Rendus.* C.

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Tabulated report of experiments made by Sub-Committee 1163 on John H. Irwin's Steam Injector and Ejector: being a portion of the Report first read by the Committee of Science and Arts of the Franklin Institute Dec 3rd 1879

Experiments upon the Irwin Steam Injector, by the sub-committee of Science and Arts of the Franklin Institute. First Series.

	Observed Data											Delivery			Check					Duty		
1 Number of Experiment	2 Duration of experiment (Minutes)	3 Height of Barometer (Inches)	4 Temperature of Atmosphere (Deg. Fahr.)	5 Steam pressure above atmosphere (Lbs per sq inch)	6 Water pressure (Lbs per sq inch)	7 Steam used (Lbs)	8 Feed water lifted (Lbs)	9 Temp. Feed water (Deg. Fahr.)	10 Water & Steam delivered (Lbs)	11 Temp. delivered water (Deg. Fahr.)	12 Height of Lift (Feet, Inches)	13 Water delivered per lb of steam (Lbs)	14 Water delivered per minute (Lbs)	15 Water Heat (θ)	16 Units of heat in delivered water (Heat units)	17 Units of heat in feed water (Heat units)	18 Units of heat in 1 lb of steam used (Heat units)	19 Error of Experiment (Heat units)	20 Percentage of Error (Per cent)	21 Total head (Feet)	22 Work done in lifting and forcing per lb of steam (Foot lbs)	23 Duty of Injector per 100 lbs of coal = 900 lbs steam (Foot lbs)
1	15	29.95	75°	5	15	20.5	471.5	102.5°	492	104°	7' 4"	23	31.43	No attempt was made to determine the injector in first eight experiments	1728	705.5	1026.5	−132.	7%	42	1108	907 200.
2	5	29.93	80°	1.	15	5.	170	62.5°	176	98.5°	5' 1⅞	34	34		2427.5	1051	1290.5	+127.	5.4%	42.5	1467.5	1.265 750
3	15	29.93	78°	50	50	52.75	703.75	62.5°	756.5	142°	8' 6¼	13.37	49.03		1384.5	407.5	1176.7	+11.1	0.7%	77.75	1117.26	1.005 530
4	10	29.9[illegible]	82°	50	50	15	373.5	64.5°	388.	113°	9' 3⅝	24.9	37.35		2101.	811	1291.	+120.	6%	78.5	2033.15	1.829 835
5	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70°	[illegible]	122°	[illegible]	21.06	44.9[illegible]		[illegible]	[illegible]	[illegible]	+113.	5%	110.05	2440.94	2.196 845
6	10	[illegible]	[illegible]	[illegible]	[illegible]	23	411	68°	434	126°	7' 9¼	17.87	41.10		1777.5	643.1	1133.6	−37.5	2.1%	111.31	2100.42	1.890 377
7	10	29.81	[illegible]	60	60	23.5	476.5	68°	521.	130°	9' 0½	19.84	49.50		2024.2	703.8	1320.4	+144.7	7.1%	147.	3019.38	2.717 442
8	15	29.81	72°	75	75	45.	779.	60.5°	824	124°	9' 1⅝	17.31	54.93		1667.6	493.5	1174.	+14.6	0.9%	161.04	3326.14	2.993 574
9	15	29.95	64°	90	90	39	786.5	69.6°	825.5	141°	7' 1⅝	13.34	55.03	0.57	1625.	500.5	1124.5	−38.5	3.6%	214.16	3071.05	2.763 948
10	15	29.94	63°	90	90	53.75	466.25	69°	520	182°	7' 9¼	8.67	31.08		1455.7	320.9	1134.8	−48.2	3.3%	214.51	2077.21	1.869 490
11	15	29.95	64°	100	100	41.5	779.	68°	840.6	150°	8' 6¼	12.66	57.93	0.62	1616.	436	1180	−26.	1.6%	250.04	3413.81	3.072 237.
12	5	29.95	66°	[illegible]	100	66.75	480.25	68°	541.	174°	9' 2½	7.9	32.06		1414	234.	1184	−22.	1.5%	250.71	2281.32	2.008 187
13	15	29.91	64°	[illegible]	30	30.	342.25	68°	372.25	123°	14' 8¾	16.07	24.8[illegible]		1758.4	650.9	1067.5	−78.	4.5%	83.75	1647.10	1.437 400
14	15	29.92	65°	60	60	36.5	625	69.6°	661.5	123°	15' 5⅞	17.12	41.66	0.96	1833.7	607.7	1226	+30.3	2.7%	153.33	2778.34	2.500 505
15	15	29.47	57°	60	60	38.5	602.5	63.5°	641.	132°	14' 4½	15.65	40.16		1668.5	495.1	1175.0	−0.5	0.0	152.38	2536.62	2.282 964
16	10	29.97	56°	90	90	39.	359.5	64°	398.5	167°	14' 11	9.22	35.95	0.87	1384.1	295.1	1089.	−93.9	6.8%	221.22	2268.02	2.041 219
17	10	29.95	56°	90	90	37.5	411.	63°	448.5	150°	15' 4½	10.96	44.10		1416.9	341.6	1075.4	−107.5	7.6%	222.25	2659.30	2.393 375
18	15	30.61	50°	90	90	63.5	997.5	49.5°	1061	116°	61' head	15.71	[illegible]	0.43	1405.8	274.4	1130.4	−52.	3.7%	206.46	3449.94	3.104 951.
19	15	30.60	48°	70	90	65	432	66.5°	497.	200°	111' head	6.65	[illegible]		1270.8	162.1	1127.9	−55.	4.3%	206.66	1576.36	1.418 723
20	15	30.60	49°	60	60	51	335	55°	386	114°	3' lift	16.37	55.66		1424.9	376	1053.9	−121.5	8.5%	138.25	2401.40	2.161 262

Note. Column 16 is found by dividing the number of lbs of Water and Steam delivered by lbs of Steam used & × by the specific heat of temperature of delivered water above 32°.

Column 17 is found by ~~dividing~~ multiplying the number of lbs of Water delivered by the specific heat of temperature of feed water above 32°.

Column 18 is found by subtracting the one from the other. & Column 19 is found by comparing column 18 with the corresponding theoretical heat as given in Regnault's tables.

Second Series of Experiments

Number of Experiments	Temperature of feed water (Degrees Fahrenheit)	Height of lift (Feet & inches)	Absolute Steam Pressure (Lbs per sq inch)	Without Waste: Augmented Pressure (Lbs per sq inch)	Without Waste: Ratio Press. Water / Press. Steam (R)	Without Waste: Temp. delivered water (Degrees Fahrenheit)	With Waste: Augmented Pressure (Lbs per sq inch)	With Waste: Ratio Press. Water / Press. Steam (R.)	With Waste: Temp. delivered water (Degrees Fahrenheit)	Temperature of Atmosphere (Fahrenheit)	Height of Barometer
1	42°	0.11¾"	105	190	1.81	165°	345	3.29	184°	82°	30.7
2	45°	1.1½"	95	175	1.84	180°	325	3.30	167°	"	"
3	45°	1.4"	85	165	1.94	196°	320	3.77	191°	"	"
4	43°	1.5½"	75	160	2.13	178°	275	3.66	180°	"	"
5	43°	1.7"	65	150	2.31	168°	255	3.92	168°	"	"
6	54°	0.7"	55	123	2.24	131°	200	3.63	134°	"	"
7	44°	1.2½"	45	90	2.00	116°	190	4.22	130°	"	"
8	36°	1.5½"	35	80	2.29	120°	125	3.43	123°	"	"
9	30	1.11"	25	60	2.40	144°	106	4.24	155°	"	"
10	40°	1.8"	16	40	2.50	91°				"	"
11	38°	1.10"	14	30	2.14	83°				"	"
12.	36		10	25	2.50	85°				"	30.65

Note. The augmented pressures in these experiments were taken while the injector was working steadily but would have broken with a slight increase of pressure.

The steam & air pressures in the [illegible] columns and are computed by adding 15 lbs to the gauge pressures.

Third Series of Experiments

Number of Experiments	Absolute Steam Pressure (Lbs per square inch)	Water pressure absolute (Lbs per sq inch)	Height of lift (Feet and inches)	Temperature of feed water (Degrees Fahrenheit)
1	7½	15	0.0	68°
2	8½	15	0.0	70°
3	16	16	0.4½"	77°
4	20	20	0.6¼"	80°
5	20	30	0.6¾"	84°
6	25	25	0.9"	98°
7	30	30	1.2"	100°
8	30	30	1.3⅞"	108°
9	45	45	1.7	122°

Note. The injector refused to work at higher pressures with the low temperature of feed water and broke at the pressures and temperatures given in the table. The steam & water pressures are absolute pressures.

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MINERALOGICAL NOTES.

By Wm. H. Wahl, Ph.D.

In *mineralogy* the usual amount of activity has been displayed during the past year, though the record is not so interesting as that of the preceding year. In chemical mineralogy especially there have been some highly important researches that have added a number of new elements to science. The mineral samarskite, which has already yielded two new elements, phillipium and decipium, is affirmed by Boisbaudran to contain still another, to which he has given the name of *samarium;* while gadolinite, which in 1878 yielded ytterbium to Marignac, contains, according to Nilson, a new element, *scandium.* The same new radical is affirmed to have been detected in yttrotitanite, and Clève, who has investigated the earth erbia, which yielded ytterbium to Marignac, affirms the existence therein of two other new metals, *holmium* and *thulium.* From the copper-nickel of Kragerö (Norway) Dahll has succeeded in isolating what he affirms to be a new metal, which he calls *norwegium.—Am. Jour. Sci. and Arts,* xvii, 478; xviii, 141, 400, *et seq.*

Delafontaine affirms that he has succeeded in detecting Marignac's ytterbium in the mineral sipylite from Amherst, Va., and W. G. Brown claims to have observed the spectrum lines characteristic of Delafontaine's phillipium in the same mineral. The existence of a new member of the platinum group from the Ural is also re-affirmed, and given provisionally the name *ouralium.* How many of these alleged discoveries will stand the test of future investigation it would be hazardous to predict. Time alone can bring order out of what appear, at least in the case of several of the above new (?) elements, to be conflicting discoveries.

Mr. S. B. Christy contributed an important paper to the California Academy of Sciences, on the *Genesis of Cinnabar deposits,* to determine the question whether these deposits were formed by deposition from solution or by sublimation. The author shows that cinnabar is soluble in alkaline sulphides at temperatures between 150° and 250°C. and at pressures of from 200 to 500 pounds per square inch. He holds that the preponderance of evidence is in favor of the view that the deposits of cinnabar as they exist at present, *in situ*, are the result of deposition from solutions in alkaline menstrua, under conditions not unlike those by which he has succeeded in producing the mineral artificially.—*Proc. Acad.*, 1879.

The artificial production of *pyroxene* was accidentally accomplished and noticed by Messrs. Thomas and Gilchrist in the operation of manufacturing the basic bricks for lining the walls of the Bessemer converter which forms an important element of their process for manipulating phosphoretic pig iron. Those bricks are made of an aluminous magnesium limestone, subjected to a very high temperature in a furnace lined with siliceous fire-bricks; where the lower portion of the charge had come in contact with the siliceous lining a decomposition and partial fusion had taken place. Portions of the fused mass were distinctly crystallized in prismatic crystals of the monoclinic system, semi-transparent, and from colorless to green in color. Hardness 5+, and specific gravity 2·934. Analysis showed it to be a bi-silicate and a true pyroxene.

Of other contributions to chemical mineralogy, it will be useful to note the fact that F. D. Adams has determined the very general existence of chlorine in members of the *scapolite* family; C. Doelter has added considerably to our knowledge of the correct composition of *spodumene* and *petalite*, and Rammelsberg to that of the *lithia micas;* and Tisani shows that *wagnerite* is identical with kjerulfine. The following new localities and occurrences of minerals are worthy of notice. Genth has identified with *pyrophyllite*, a mineral found by Reinhold in the coal slates of the North Mahanoy Colliery, in Schuylkill Co., Pa., filling out cavities in the slates, and as the petrifying material of coal plants. (*Proc. Am. Phil. Soc.*, xviii, 279). As the result of Mr. Edison's circular of inquiry, the presence of *platinum* has been determined in numerous localities in Idaho, Dakotah, Washington Terr., Colorado, Arizona, New Mexico and British Columbia. In some of these localities the metal is affirmed to exist in considerable quantities.

Dr. Genth's examination of a new locality of *uranium minerals* at the Flat Rock mine, N. C., has yielded some valuable facts concerning the genesis of these species. (*Am. Chem. Jour.*, i, 87). The rounded masses in which they occur were found to contain, in many cases, a nucleus of uraninite; surrounding this is an orange-colored mineral, gummite, and interpenetrating it and forming a crust over it, a light yellow mineral, identified as uranotil. Dr. Genth affirms that gummite is a mixture of uranium hydrate (40·10 p. c.), uranotil (33.38 p. c.), lead uranate (22·66 p. c.) and barium uranate (4·26 p. c.). He also observes autunite at the same locality, associated with phosphuranylite, a new species, described elsewhere. Dr. E. Goldsmith reports the occurrence of *amber and asphaltum* in the ash marl of the cretaceous, at Vincentown, N. J. The last named is found occasionally in masses of 100 pounds weight. The amber is thought to be related to the kranzite of Bergemann. (*Acad. Nat. Sci. Proc.*, 1879). *Percylite* and *schwartzenbergite* are reported to have been found at a new locality in Bolivia. Extensive deposits of a *mineral wax* have been discovered in Utah. The locality is in the Wasatch Range, on the head waters of the Spanish Fork, east from the south end of Utah Lake. The material, variously described as ozocerite and zietrisikite by Newberry and Wurtz respectively, who differ as to its identity, is found saturating beds of bluish shales of (probably) tertiary age, over a tract of country 50 to 60 miles in one direction by 20 miles in another.—*Eng. and Min'g Jour.*, Dec., 1878—Jan., 1879.

Claasen has identified *cacoxenite* on the martite of Lake Superior. It appears in acicular crystals of brown yellow color, forming radiating tufts. Dr. J. Lawrence Smith has made an elaborate investigation of the *native iron* of Ofivak and other localities in Greenland (*Ann. de Chim. et de Phys.* (V), xvi.) hitherto believed to be of meteoric origin, and affirms them to be terrestrial. B. Silliman notices that the rare mineral *jarosite* occurs quite abundantly in the quartz veinstone of the Vulture mine in Arizona.—*Am. Jour. Sci.*, xviii, 73.

Maskelyne describes rock masses from two localities in the Transvaal in South Africa, consisting solely of massive *enstatite.*

For the benefit of those readers of the JOURNAL who may be interested in the subject, an alphabetical list of the new mineral species and varieties that have been described in the journals during the year just passed is herewith appended, together with a brief description of the more important members of the list.

ABRIACHANITE—a doubtful species—described by Heddle, and named provisionally with several other substances, "which may prove to be new Scottish minerals." It is described as an impure, bluish, clay-like mineral.—*Min. Mag.*, 1879, 57. *Am. Jour. Sci.*, xviii, 484.

ANIMIKITE, an antimoniuret of silver, resembling metallic silver, which its discoverer holds to be a new member of the dichrasite family. Found at Thunder Cape, near Silver Islet, where it was taken for native silver. Described by Dr. Henry Wurtz.—*Eng. and Min'g Jour.*, Feb. 22, 1879.

BERNARDINITE, a new mineral resin from San Bernardino Co., Cal. A light, porous, friable mass of yellowish-white color, that floats on water; dissolves readily in alcohol, ether or potassa, and forms an emulsion with water on boiling. It is probably a mixture of several resins. Described by J. M. Stillman.—*Min'g and Sci. Press*, 1879.

BHRECKITE, a chloritic mineral named provisionally by Heddle as a probable new Scottish mineral.—*Ref.* Abriachanite *ante.*

BRASS (native). Specimens of what appear to be a native brass are reported to have been found on the Yuba river in Sierra Co., Cal. They are described as being in the form of small, flattened, concretionary masses, destitute of crystalline structure, yellowish to red-brown in color, with a faint yellowish streak. Comp. 85·02 p. c. copper, 11·02 p. c. zinc. Described by J. M. Stillman.—*Ref.* Bernardinite *ante.*

CLINOCROCITE, a hydrous sulphate found at the Bauersberg, near Bischofsheim. Described by S. Singer.—*Ref.* Abriachanite *ante.*

CLINOPHAEITE, a hydrous sulphate. Same locality. Singer.—*Ref.* Abriachanite *ante.*

EGGONITE, a new silicate (containing cadmium ?) occurring in minute crystals of a brown color on calamine from Altenberg, near Aachen. Described by Schrauf.—*Zeitsch. Kryst.* iii, 352.

FAIRFIELDITE, a hydrous phosphate of manganese and calcium with small quantities of iron and sodium; found associated with *reddingite* and *fillowite*, at the new mineral locality at Branchville, Fairfield Co., Conn. Its color is yellowish white to colorless and transparent, with adamantine lustre on the best cleavage planes. Described by Brush and E. S. Dana.—*Am. Jour. Sci. and Arts*, xvii, 259, *et seq.*

FILLOWITE, a hydrous phosphate of manganese, sodium and iron. Found at the same locality as the mineral just described. Occurs in crystalline masses, and rarely in distinct crystals of a wax yellow to brown color, at times almost colorless. Crystallization monoclinic. Described by Brush and E. S. Dana.—*Ibid.*

GEDONITE, a fossil resin occurring with the amber of the Baltic, and distinguished from the latter by its greater friability, lower point of fusion and more ready solubility. Described by Helm.—*Eng. and Min'g Jour.*, March 13, 1879.

HANNAYITE, a hydrous phosphate of magnesia and ammonia found in the guano of the Skipton caves in Victoria, N. S. W. Crystallization triclinic, with perfect basal cleavage. Described by Vom Rath.—*Vide, Newberyite*

HERRENGRUNDITE, a basic cupreous sulphate, found associated with gypsum, malachite and calcite from Herrengrund, Hungary. Crystallization monoclinic (?) with perfect basal cleavage; color dark merald green. Described by Bretzina.—*Zeitsch. Kryst.*, iii, 359. *Am. Jour.* xviii, 484.

HOFMANNITE occurs in colorless, tasteless, tabular crystals in lignite, with a composition $C^{20}H^{36}O$. Described by Bechi (Pisa).—*Ibid.*

HOUGHTONITE, a new species (?) of mica from the hornblendic gneiss of Roneval, Scotland. It has a jet black color, transmitting brown light in thin plates. Described by Heddle.—*Ibid.*

HUNTILITE, a new arsenide of silver found at Silver Islet, Lake Superior. Two varieties are found, the most abundant being amorphous or cryptocrystalline and of a slate gray to black color, while a crystalline variety is of a light slate color. Both varieties are somewhat malleable under the hammer, and take a burnish when rubbed with a knife blade. They give a lustrous bronze streak on ground glass. The discoverer holds the affiliations of huntilite to be with the dichrasites and domeykites, regarding it properly as a silver domeykite, but constituting the first member of a new series of mineral homologues. Described by Wurtz.—*Eng. and Min'g Jour.*, Jan. 25th, 1879.

LEUCOMANGANITE, a snow-white, foliated and radiated mineral, colorless in thin plates, but fusing readily before the blowpipe with brownish discoloration. Chemical composition not accurately known, but containing manganese and iron protoxides, alkalies and water. Described by Sandberger.—*N. Jahrbuch f. Min* , 1879, 370.

LOUISITE, a hydrous silicate of lime and potassa with small quantities of iron (protoxide), found at Blomidon, N. S. It is a leek-green, translucent, vitreous mineral, brittle with splintery fracture, and gelatinizes with hydrochloric acid. Analyzed by H. Louis and named by D. Honeyman.—*Am. Jour. Sci.*, xviii, 484.

MALLARDITE, a new hydrous sulphate of manganese found at Lucky Boy silver mine, Utah. Occurs in small fibrous, monoclinic crystals, at first colorless and transparent, but which soon effloresce on exposure to the air, losing two equivalents of water. Described by A. Carnot.—*Jour. Chem. Soc.*

NEWBERYITE, found with hannayite in the guano of the Skipton

Caves, Victoria, N. S. W. A hydrous phosphate of magnesia; crystallization orthorhombic. Described by Vom Rath.—*Bull. Soc. Min. France*, 1879; *Am. Jour. Sci.*, xviii, 487.

Plagiocitrite, a new hydrous sulphate from the Bauersberg, near Bischofsheim. Described by Singer.—*Am. Jour. Sci* , xviii, 484.

Phosphuranylite, a new hydrous phosphate of uranium, found at the Flat Rock mine, in Mitchell Co., N. C., occurring in the mica-bearing portion of a large granite vein with other uranium minerals. Found as a thin coating on quartz, feldspar and mica. The mineral has a deep lemon yellow color, and under the microscope shows minute rectangular scales of a pearly lustre. Described by Genth.—*Am. Chem. Jour.*, i, 87.

Randite, a hydrous carbonate of calcium and uranium found as a lemon-yellow incrustation on granite near Philadelphia. The mineral is related to liebigite. Described by Koenig.—*Acad. Nat. Sci. Proc* , 1878, 408.

Reinite, a tungstate of iron, isomorphous with scheelite and scheeletine, brought from Japan (Kimbosan) by Dr. Rein. Found associated with quartz, forming large, well-developed crystals of brownish-black color, closely resembling those of the above-named minerals. Described by Dr. Luedecke.—*N. Jahrbuch f. Min.*, 1879, 568.

Titanomorphite, a titanate of lime, held to be the product of the alteration of titanium minerals (ilmenite and rutile). It is found in hornblende slate near Reichenbach, in Silesia, surrounding crystals of rutile. It has a yellowish-white color, and a granular or fibrous texture. Described by von Lasaulx.—*N. Jahrbuch f. Min.*, 1879, 568.

Urusite, a hydrous sulphate of ferric oxide and soda, found in the Caucasus associated with gelbeisenerz and copperas. Color from lemon-yellow to orange, and is found in bulbous masses (or pulverulent), which, when crushed, show the glitter of the small crystals of which the mass is made up. Described by Frenzel.—*N. Jahrbuch f. Min.*, 1879, 89.

Urvölgyite (see Herrengrundite, *ante*). Szabó, who describes this species, differs from Brezina in making the lime obtained in the analysis an essential constituent of the mineral, while the latter ascribes it to the presence of gypsum.—*Tsch. Min. Mittheill*, ii, 311.

Wattevillite, a hydrous sulphate found at the Bauersberg, near Bischofsheim. Described by Singer.—*Am. Jour. Sci.*, xviii, 484.

Xantholite, a mineral having nearly the composition of staurolite, but thought to have a monoclinic crystallization. Described and named provisionally by Heddle, as a probable "new Scottish mineral." —*Min. Mag.*, 1879, 57.

Of new varieties, the following are of special interest:

A *titaniferous crysolite*, having a red color, and containing 6·10 p. c. of titanic acid, has been found at Zermatt, Switzerland. Described by Damour.—*Bull. Soc. Min. France*, ii, 15.

A *gelatinous silicate*, found near Lausanne, Switzerland, has the consistency of paste when taken out, but gradually solidifies. It has the composition of chabasite. Renevier, who described it, calls it "a mineral in an embryotic condition."—*Bull. Soc. Vaud*, xvi, 21; *Am. Jour. Sci.*, xviii, 72.

A *mangano-calcite*, carrying 2·04 p. c. of barium carbonate, occurs in a crystalline limestone at Laangban. Described by Sjogren.

A *barytic feldspar*, carrying over 7 p. c. of baryta, is described by Descloiseaux. Cleavage angles were identical with those of labradorite, while its optical properties allied it with albite and oligoclase. Locality was unknown, but the mineral resembled the albite from Steiermark.

LUCKITE, a new variety of ferrous sulphate. It is found in small distorted crystals, probably monoclinic, having a slight tinge of blue. The mineral carries a small percentage of manganese; composition $SO^4(Fe\ Mn) + 7H^2O$. Ratio of Mn to Fe as 1 : 10. It is regarded as being intermediate between melanterite and mallardite, but differs from both by not altering on exposure to air. It occurs at Lucky Boy silver mine, Utah, and is described by Carnot.—*Jour. Chem. Soc.*

In crystallographic mineralogy, it may be interesting to note that Streng, from a study of the optical characters and an accurate measurement of the angles of the crystals of *pyrostilpnite* (fireblende), pronounces this mineral to belong to the orthorhombic and not to the monoclinic system; and that Baumhauer, from an investigation of the etching figures produced on crystals of *boracite* by acids, is led to the conclusion of Mallard, that the species belongs to the orthorhombic and not to the isometric system.

Magnetic Influence on Atmospheric Polarization.—Henri Becquerel infers, from recent observations upon skylight polarization, the existence of a variable difference between the solar plane and the plane of polarization, and the manifestation of a magnetic influence by the earth upon the atmosphere.—*Comptes Rendus.* C.

SILK CULTURE.

By Sam'l Chamberlaine, M.D.

The United States Agricultural Report from the Census of 1870 contains, at page 241, the following passage respecting silk culture: "In consequence of the diseases of the silkworm, the imports of raw silks into Great Britain have fallen off 40 per cent., and prices have risen 100 per cent. Imports of silk from China between 1857 and 1864 fell from nine millions of pounds to three millions of pounds. To remedy this evil, the silk manufacturers of England have formed a company, 'The Silk Supply Association,' the object of which it to stimulate silk production by cottage culture."

The notice thus given of a deficiency in this important article of luxury, the producing and manufacturing of which has been so largely productive of wealth to three great countries—China, Japan and France—drew renewed attention to the subject in the United States, and induced in several parts of the country a desire to repeat the efforts made in 1830 to 1840, but upon a better and wiser method than was pursued at that period. It was remembered by many that the originator of the silk excitement in that decade (M. D'Homergue, a native of the silk provinces of France and brought up amongst silk-growers) had declared his belief "that the United States are destined to become a great silk-growing and silk-manufacturing country; that the fulfillment of this high destiny may be retarded, but nothing can prevent its taking place at some future time" (page 63 of letters to Mr. Peter S. Duponceau).

The development of the unhappy excitement of that period into a wild and wicked speculation in mulberry trees proved that this industry could not be made sufficiently profitable to any individual to induce the prosecution of it alone; that it requires combination, both of individuals to cultivate the silkworms on a sufficiently large scale, and of capital to regulate the purchase and sale of the silk products. The English idea of *cottage culture*, stimulated and regulated by an organized company, is being pursued in their Australian colonies. We saw something of their success during the Centennial Exhibition of 1876. It remains for us Americans to adopt and apply to our own country the wise suggestion and example they have given us. To further this hoped-for application the following statistics are presented through the JOURNAL OF THE FRANKLIN INSTITUTE. And first in regard to the whole silk supply of all the silk-producing countries. It appears that there is at all times a relative deficiency, *i. e.*, that the supply is subject to very great and very sudden fluctuations as to quantity, and that while on the whole there is a general increase of production, this does not keep pace with the increase of demand. The adulterations and the intermixture of other textile fibres of less strength and less durability fill the demand for the time. It would be much better filled by the silk alone, were the production itself increased. It is therefore true that in the world's markets there is always ready sale for raw silk. The statistics presently to be introduced will show that in our own markets there is a steadily and rapidly increasing demand for it. The irregularity of the production is very forcibly shown by the following table of prices at London, taken from Secretary Wyckoff's "Silk Goods in America" (published in 1879):

		Chinese Tsaltee, No. III.			Japan Maibash.			Italian best Organzine.	
		s.	*d.*		*s.*	*d.*		*s.*	*d.*
	1860	23	6		27	6		43	6
Av. 24s. 1d. $6.00	1861	19	6	Av. 28s. 1d. $7.00	24	0	Av. 36s. 9d. $9.18	40	0
	1862	23	0		28	0		31	0
	1863	22	0		24	6		35	0
	1864	25	6		28	6		32	0
	1865	31	0		35	6		46	0
Av. 29s. 1d. $7.25	1866	26	0	Av. 33s. 3d. $8.30	30	0	Av. 46s. 4d. $11.60	37	0
	1867	32	0		36	0		50	0
	1868	29	0		33	0		60	0
	1869	30	0		35	0		45	0
	1870	29	0		32	6		40	0
Av. 22s. 4d. $5.60	1871	29	0	Av. 24s. 0d, $6.00	29	0	Av. 38s. 4d. $9.60	44	0
	1872	28	6		30	0		46	0
	1873	21	6		24	6		38	0
	1874	18	0		21	6		35	0
	1875	17	0		15	0		29	0
Av. 24s. 6d. abt. $6.00	1876	28	6	Av. 25s. 9d. abt. $6.40	33	6	Av. 38s. 3d. abt. $9.50	46	6
	1877	20	6		18	0		30	0

It is of interest to know what may be the product of the whole silk-producing countries of the world, and attempts have been made to arrive at some probable estimate, notwithstanding the difficulty of collecting statistics from so many countries and from such variety of returns. Two tables of approximate results we present below, the one taken from the *American Exchange and Review* for October, 1870, and the other from Dr. Brockett's *Silk Industry*, published, in 1876, under the auspices of the Silk Association of America, and for the Centennial Exhibition. Both tables give only the value in dollars, but, as it is desirable to form an idea of the production in pounds, I have used a table of Dr. Brockett's work (page 203) to obtain an average price per pound, and from it to deduce the amount of silk supposed to have been furnished by each silk region:

Country.	Av. value.	Total value.	Estimated in lbs.	Total value.	Estimated in lbs.
		1870.		1876.	
Chinese Empire...	$4	$81,600,000	20,400,000	$92,928,000	23,232,000
Italy and Pontifl. States..............	8	40,500,000	5,065,000	59,250,000	7,406,000
India..................	3	24,000,000	8,000,000	35,200,000	11,733,000
France................	8	25,000,000	3,125,000	31,246,800	3,903,000
Japan and Corea..	4	18,100,000	4,525,000	19,800,000	4,950,000
Syria and Asia Minor..............	6	7,000,000	1,166,000	8,500,000	1,416,000
Turkey in Europe	6	7,000,000	1,166,000	7,920,000	1,320,000
Persia, Turkistan, etc..................	6	6,400,000	1,066,000	6,250,000	1,041,000
Austria and Hungary..................	8	1,280,000	156,000	3,087,000	386,000
Spain & Portugal	7	3,200,000	457,000	1,884,000	269,000
Greece.................	6	840,000	140,000	1,087,000	181,000
Morocco..............	6	300,000	50,000	300,000	50,000
America (probably Mexico, Brazil & California)	6	80,000	13,000	100,000	16,000
		$215,300,000	45,333,000	$267,553,400	55,903,000

This table shows the sources of the world's supply of raw silk, and the importance, in money value, of the industry to those countries. It shows a much wider distribution of the industry than is commonly supposed to exist. It shows, also, the almost total neglect of this valuable product on the Continent of America; while the exhibit of a paltry 16,000 pounds proves that somewhere it is being made, and therefore that a much more extensive production is possible. It shows that the long-settled and densely populated countries are those that produce the greatest quantity, and we may infer that a certain degree of concentration and stability of population is necessary to its successful pursuit. The increase in the six years interval between these tables has been about 25 per cent., that is, about 4 per cent. per annum during a period of unusual and wide-spread inactivity in business, which has lessened the consumption of silk goods greatly more than of any other material of wear, silk being necessarily classed amongst the luxuries, and not among the necessaries of life. This rate of supply must fall far short of the demand when the increased activity of all trade shall increase the consumption of silk goods also in a like ratio. Hence the importance of effort on the part of Americans to add this product to our present industries, since there is sure to be a large and increasing demand for it within a few years. But a very important part of the usual supply is known to have been steadily decreasing during the past fifteen or more years. Italy and France together have furnished about one-fifth of the whole. In these countries the diseases amongst the silkworms have prevailed, and have shortened their crops continually, year by year, as the following table, from Secretary Wyckoff's work (page 12), will show in regard to Italy, and no doubt a like return from the French districts would show a similar decrease.

Annual Silk Product of Italy.

Before the Pebrine disease, 3,710,000 kilos.

in 1863	2,308,000	"	loss,	38	per cent.
1864	1,731,000	"	"	53	"
1865	1,762,000	"	"	52	"
1866	1,800,000	"	"	51	"
1867	2,000,000	"	"	48	"
1868	1,900,000	"	"	49	"
1869	2,150,000	"	"	42	"
1870	3,180,000	"	"	14	"
1871	3,473,000	"	"	6	"
1872	3,125,000	"	"	16	"
1873	2,960,000	"	"	20	"
1874	3,430,000	"	"	7	"
1875	3,073,000	"	"	17	"
1876	1,010,000	"	"	72	"
1877	1,853,400	"	"	50	"
1878	2,650,000	"	"	28	"

The average annual product for these sixteen years was 2,400,338 kilos., which is 1,309,662 kilos. less than the annual product before the disease assailed them. This amount, estimated in pounds avoirdupois ($2\frac{1}{5}$ to the kilo.), is 2,873,256 lbs. This is, therefore, the deficiency in Italy alone, and this large amount must be made up either by increasing the production in the Eastern countries, or by finding in America a new and wide field for extending it. The deficiency, in fact, is much greater than this, for it must be doubled for France, where the disease has prevailed with even greater virulence; and more than doubled, if we include, also, the countries upon the Mediterranean to which it has spread in perhaps a less degree. The existence of this disease has induced a trade of no small amount between France and Italy, as purchasers, and Japan (chiefly) as seller of silkworms' eggs. The magnitude of this trade is indicated by the statement in the *Public Ledger* of the 23d Dec., 1879, that six freight cars filled with cards of silkworms' eggs had arrived from San Francisco at New York, on the way from Yokahama, Japan, to Havre in France. The value is stated in the article at $850,000, but this is probably an under-statement, or the cargo is but a part of that which the same article promises will arrive in January. In the years 1874, 1875, 1876, 1877 similar cargoes passed over the Pacific Railroad, and were estimated in the papers of each of those years at $6,000,000, the numbers of the cards of eggs and their value ($5.00 per card) being stated.

There is no reason why Americans should permit this trade to pass through our borders without making an effort to participate in its profits. In truth, there have been some small invoices of eggs sent from Kansas, from Alabama and North Carolina. The expense of raising the eggs is very small, and the profits quite large in proportion, while the trade may be expected to last for a good many years to come, since the French and Italians have found advantage in a constant renewal of their stock.

This decrease of production in Europe is further shown in the following extract from the *Country Gentleman* of October, 1879, which brings the statement down to the present year:

	1878.	1879.	
Silk crop of Europe......	7,326,000 lbs.	2,510,200 lbs.	= ⅓.
" Asia..........	11,541,200 "	12,221,000 "	= slight advance.
Total....................	18,867,200 "	14,731,200 "	= ¼ less.

Result.—Crop of 1879 less than of 1878 by 4,000,000 lbs.
and less than the average of 5 years by 3,960,000 "

While there is shown to be a lessened supply of raw silk, we have abundant evidence that the consumption of it in the United States is continually increasing, and that steadily so that something like a rule seems to be exhibited by the statistics of its importation. The rate of increase appears to be, that the average annual importation doubles every five years. The manufactures by American silk mills have so grown in popularity that the domestic goods have succeeded in gaining half the United States market from the foreign manufacturers, and the number of firms engaged in this work has increased at the rate of 50 per cent. in four years, as the following, from Dr. Brockett's work, shows:

Firms reporting to the Silk Association.

May,	1873,	147	firms,	employing	11,713	operatives.
"	1874,	156	"	"	10,651	"
"	1875,	180	"	"	14,479	"
"	1876,	213	"	"	18,017	"

These firms have produced silk goods of the value of $25,000,000 in 1872 to $27,000,000 in 1876, and have gained upon the foreign importations at the following yearly rates:

Calendar Year.	Home Production.		Importation.		United States Consumption.	Proportion per cent.
1872	$25,073,201	+	$32,677,749	=	$57,750,950	43·4
1873	19,894,874	+	24,379,322		44,274,196	44·6
1874	20,082,482	+	23,292,551	=	43,375,033	46·3
1875	27,158,071	+	23,168,118	=	50,326,189	53·9
1876	26,593,163	+	21,192,386	=	47,785,549	56·4
1877		+	19,922,741	=		
1878		+	20,042,730	=		

When the values of home production for the years 1877 and 1878 are ascertained it will be found that the proportion to the amount imported has not lessened, although the total of consumption will probably be less, in accordance with the continued depression of general business in those years. The table bears out the assertion that our silk mills are gaining possession of our home market, and that by not slow steps.

Previous to 1850 the number of firms engaged in importing and manufacturing raw silk were so few and the amount so insignificant that no separate account was taken at Washington of the importations, nor was the quantity of raw silk noted until the end of the fiscal year (June 30th) 1864. The business of manufacturing rises into importance only after 1850, when the success attained by Mr. John Ryle, at Paterson, N. J., had attracted others to engage in the business. It should not be forgotten by those who think the "Morus Multicaulis Mania" was all loss to the country, that out of it arose the thirty (now perhaps fifty) firms at Paterson, and the city itself, with (probably)

60,000 inhabitants. John Ryle and Wm. H. Horstmann were brought over from the English silk mills in which they were employed, by reports of the great amount of silk that was being produced in the United States. They both established the large firms of which they were the heads, the one in Paterson, the other in Philadelphia. These were the outcome of Samuel Whitmarsh's failure. They were both employees of the great "King of Multicaulis," as Whitmarsh was called.

The growth of the silk business is best shown by reducing the extensive tables (from Washington) found in Dr. Brockett's work to averages for the half decades:

Fiscal years (inclusive).	Average No. lbs.	Total value for 5 years.	Annual cost.
1851 to 1855.........	not stated	$3,467,384	av. $693,477
1856 to 1860.........	not stated	6,347,425	av. 1,269,485
1861 to 1865.........	av. 348,978	6,503,365	av. 1,300,673
1866 to 1870.........	av. 575,524	12,555,337	av. 2,511,067
1871 to 1875.........	av. 1,044,005	27,789,815	av. 5,557,963

During the five years, 1860 to 1865, the civil war lessened the rate of increase, but did not break up the business, nor even prevent a slight increase of the importation. In the second five the amount was nearly doubled, in the third stationary (on account of the war), in the fourth almost double again, and in the fifth more than doubled. We might fairly expect to find the annual amount stationary again during the period from 1875 to 1880, but the promise thus far is of a large increase, and perhaps with the sudden increase in all other businss this also may show a continuance of its rate of doubling, when the returns for 1880 are ascertained. For three years of the period we have the following:

Fiscal year.	No. lbs.	Annual cost.
1876,	1,144,860	$11,874,570
1877,	1,007,504	8,456,341
1878,	1,590,633	6,807,725

The last year showing a very large increase in the quantity imported, while the year 1876 was an exceptional year as to price, which rose to more than double its usual value, and to an average for the year of $10.37 per pound as against the usual average of about $5.00 (plus importer's charges).

It may be gathered from these statistics that there is in the United

States an established, settled business in silk manufacturing; that it employs at least 200 firms and some 20,000 operatives, who consume more than 1,000,000 pounds of raw silk, for which more than $5,000,000 have been annually sent out of the United States, and that the annual export of gold for this raw material will soon reach $10,000,000, and probably in the near future $20,000,000. All this may be readily produced in our own country, and a large part of it in the State of Pennsylvania, which in 1844 produced some of the best silk then used by Mr. John Ryle's "Murray Mills," in Paterson. It needs but a discreet following of the example set us by the English Society to encourage in every practicable way the raising and reeling of silk as "a cottage culture" and a country production. An association, whose headquarters should be in Philadelphia, would be able to institute, and then foster and encourage, the industry in all parts of the country. It would distribute trees, eggs and apparatus to every favorable locality; it would gather up the cocoons for reeling and the reeled silk itself from all parts of the country; it would be able to sort and sell at wholesale to the consumers the quantities and qualities suitable for their business; it would so regulate the entire business as to prevent the recurrence of mad speculation by which alone the prospects of establishing the rich industry were dashed in 1840; it would enable us to see fulfilled the first part of M. D'Homergue's prediction, as we already see by the tables that the second part has been fulfilled. The United States have become a rich silk manufacturing country; it remains for us to make her a rich silk growing country.

December 26th, 1879.

A STATEMENT CONCERNING THE RELATION OF THE LAWFUL STANDARDS OF MEASURE OF THE UNITED STATES TO THOSE OF GREAT BRITAIN AND FRANCE.

By J. E. Hilgard,
Assistant United States Coast and Geodetic Survey.

United States Coast and Geodetic Survey Office,
Washington, D. C., July 8, 1879.

Sir: I submit the following statement in relation to the American, British and French standards of measure, conceived in a brief and categorical form, in order to explain statements heretofore made from this office, as well as to give trustworthy data for books of instruction.

It is desirable, for the sake of perspicuity, that the following principal statements should be made:

1st. There is no difference between the standards of weight of Great Britain and those of the United States.

2d. The standards of volume in the United States are the same as those lawful in Great Britain prior to 1826.

3d. There is no difference between the standards of length of Great Britain and those of the United States.

4th. The relation of the American and British standards to the French metric standards is not determined with extreme precision, but the legal enactments [see Annex I] will suffice for all purposes, except those of great scientific accuracy.

MEASURE OF WEIGHT.

In regard to the standards of measure in customary use in the United States, it should be observed that they have been inherited by our ancestors from England together with the common law. No enactment by Congress has ever been made declaring particular measures in the keeping of the government as standards, except the standard troy pound of the Mint of the United States at Philadelphia, which is an exact copy of the Imperial troy pound of Great Britain procured in 1827.

Elaborate comparisons, made at various times from the year 1855 up to the present date, of this troy pound, containing 5760 grains, and of the commercial or avoirdupois pound, containing 7000 grains, derived from the former, with copies of similar weights derived from the standard pound of Great Britain, have shown that there is not so much as one-thousandth of a grain outstanding between the money standards of the two countries.

MEASURE OF CAPACITY.

Of the measures of capacity, which are not measures of great precision, it is only necessary to say that the old British wine gallon of 231 cubic inches, and the old Winchester bushel, containing 2150·5 cubic inches, are the recognized standards in the United States, as they were the lawful standards before the separation of the colonies from Great Britain, no subsequent enactment having been made.

MEASURE OF LENGTH.

The measure of length, which is the yard of 36 inches, is legally in the same condition as the measures of capacity. The standard yard of

Great Britain was lawful in the colonies before 1776. By the Constitution of the United States the Congress is charged with fixing the standard of weights and measures (Art. I, Sec. 8); but no such enactment has ever been made by Congress, and therefore that yard which was standard in England previous to 1776 remains the standard yard of the United States to this day—the same being also true of the commercial or "avoirdupois" pound, and of the gallon and bushel, as above stated.

It must not be supposed that this is a matter which, in view of the great questions of public policy engrossing the attention of Congress in early years, had remained without due consideration. The journals of both houses of Congress show that committees were early appointed for the consideration of the subject. A Senate committee reported on March 1, 1791, that "it would not be eligible at present to introduce any alteration in the measures and weights which are now used in the United States." Other reports were made from time to time, and in January, 1820, a committee of the House of Representatives presented their conclusions, which were: "That little should be done; that standards conformed to those in most common use among us should be accurately made and carefully preserved at the seat of government; that correct models should be placed in different districts of the country; and that the proportions and relations between these should be ascertained."

Again, on March 11, 1822, a committee report was submitted to the same body, making recommendations for rendering "uniform and stable the measures and weights which we at present possess."

Thus, after full consideration for thirty years, it was agreed that the matter was in a satisfactory shape, in virtue of our inheritance and traditions, and that no legislation was advisable.

Finally, in 1836, an act was passed directing the Secretary of the Treasury to cause copies of the weights and measures adopted by the Department as standards, for the use of custom-houses, to be supplied to each State, "to the end that a uniform standard of weights and measures may be established throughout the United States." The standards so "adopted" were those of Great Britain, as before described.

The actual standard of length used was a bronze scale of 82 inches, subdivided on silver to tenths of inches, which had been prepared for the Coast Survey of the United States by Troughton, of London. The 36 inches comprised between the 27th and 63d inches, found equal to the average of the whole scale, were taken as the standard yard, and the temperature at which this was considered to be a standard, that is to say, equal to the British Standard Yard, was presumed to be 62° Fahr. It had, however, never been directly compared with that standard, but was simply copied from Troughton's own scale without subsequent verification.

In England, the old standard yard, known as Bird's Standard of 1760, had in the meantime been found to be inadequate in definition for the increasing requirements of science, and a new set of standards of length, weight and capacity was constructed between 1816 and 1826 of such finished workmanship and precise definition as was required by the science of the time, and every effort was made to reproduce, with the greatest possible exactness, the old standard pound and yard.

Not long after this important work had been accomplished, the standards so constructed were destroyed by the burning of the Parliament buildings in 1834. They have since been reproduced by reference to all of the former accredited standards with which they had been originally compared, and are now known as the "Imperial Standards." Some fifty copies of these standards were constructed and intercompared, and certain of these have been sent to the United States. The avoirdupois pound of 7000 grains is found to agree within one-thousandth of a grain with the avoirdupois pound of the United States, derived from the Mint-pound heretofore mentioned—an agreement which leaves no question outstanding as to the identity of the units of weight of Great Britain and the United States.

The comparison of the Troughton scale heretofore mentioned with the Bronze Standard Yard, No. 41, received from Great Britain in 1856, shows the former to be longer by nearly one-thousanth of an inch in the yard, or, more precisely, 0·00085 inch. By very recent comparisons, however, made by myself at the British Standards Office between the standard Imperial yard and Bronze, No. 11, the latter was found to be 0·000088 inch shorter than the former, which may be stated in the form that it is of standard length at a temperature of 62·25° Fahr. Hence we infer that at 62° the Troughton scale is too long by 0·00076 inch, or that it is standard at 59·8 Fahr., instead of 62°, as formerly assumed; and this correction will apply to all measures that have been derived from it. This change, although sensible in operations of extreme scientific precision, is really of no consequence in ordinary practice, as it amounts only to the 1:45,000th part of the whole length—a degree of accuracy which is seldom required. The correction does not exceed the thickness of one of the lines that define the yards supplied to the States.

Extreme accuracy in this matter is beset with great difficulties, for in addition that of ascertaining for each particular bar the rate of dilatation by temperature, there is an uncertainty in regard to permanence in the length of the bars themselves. Of the two standard yards presented to the United States, one is of bronze (No. 11), and the other of Low Moor wrought iron (No. 57). These are found to have changed their relative length by 0·00025 inch in twenty-five years; the bronze bar being now relatively shorter by that amount. This subject is undergoing further investigation.

RELATION OF YARD TO METRE.

Statements in regard to this relation have varied excessively, comparison between the two standards being subject to two great difficulties: first, their different nature and definition, and second, their incommensurability in length. The metre is a platinum bar, cut to length (an *end-measure*), and standard at the temperature of melting ice (32° Fahr.) The length of the yard is defined by lines drawn on a bronze bar, standard at a temperature of 62° Fahr. The difficulty of making accurate comparisons of lengths so differently defined is at once apparent; moreover, as their relative length is such that the metre is something longer than 39·37 inches, it is necessary first to derive the latter length from the yard of 36 inches by minute subdivision into a scale of equal parts, and the addition of the odd amount, a process which involves so many successive operations that the probable error of the result is largely increased by an accumulation of uncertainties.

From these circumstances have arisen the differences in statements of the length of a metre expressed in inches. One of the earliest trustworthy comparisons was that made by Kater, giving the value, generally quoted, of 39·37079 inches. This comparison was made with one of the earlier British standards. A more recent determination is that made by Clarke, at the office of the British Ordnance Survey, between a number of the new British standards and several well-accredited copies of the metre, which give, very accordantly, a value of 39·37043 inches. It appears that in the latter observations the coefficients of expansion of the bars used were more accurately ascertained than in the former, and as between these two values the latter probably deserves the preference.

It must be observed, that since both yard and metre are material things, no legislative declaration in regard to their relative value can have any force other than to define what shall be considered lawful equivalents. This circumstance being recognized, when the metric standards were made optional in the United States, Congress, instead of stating the equivalents with excessive minuteness, as was done in Great Britain, merely defined the relation which shall be held lawful, to a degree of precision sufficient for practical purposes; thus we find in the table annexed that the lawful equivalent of a metre is 39·37 inches.

In the United States, Professor Hassler, first Superintendent of the Coast Survey, made very careful comparisons between one of the original metres and the Troughton 82-inch scale. The records of his experiments are not now extant, having been destroyed by fire in 1843, but he has published his results, viz.: One metre = 39·38092 inches of the bronze yard, reduced to 32° Fahr. He made use of a coefficient of expansion resulting from some experiments made by himself upon a brass wire, which value is much too large; but we cannot now correct his reduction, because we do not know the actual temperatures of comparison. Using Mr. Hassler's rate of expansion, viz., 0·0003783 inch in one yard, for 1° Fahr., and reducing his result to the standard temperature of the yard (62° Fahr.), his successor, Professor Bache, found the value of the metre to be 39·36851 inches of the Troughton scale, then the only accredited standard in our possession. When, however, we apply to the latter the correction of 0·00076 inch in a yard, found as above stated, and ascribe to it the rate of expansion of other bronze alloys—for instance, that found by Airy, from Sheepshank's observations, for the bronze of which the new Imperial standards are made, viz., ·000342 inch per yard—we find one metre = 39·37054 inches, as follows:

Hassler's value of metre, reduced to 62° . .	39·36851
Correction for difference in rate of expansion, . .	+ 0·00119
Correction for excess of Troughton scale in one metre,	+ 0·00084
Hassler's comparisons, corrected reduction, .	39·37054

a value which differs very little from that obtained by Clarke, although it cannot be claimed to possess the same degree of trustworthiness. In fact, if we substitute in the above reduction the rate of expansion for the bronze of the British standards recently determined by Fizeau, viz., 0·000351 inch per yard, we shall get 39·37023.

The value 39·3685 inches, derived, as above mentioned, from Mr. Hassler's comparisons, was used in the Coast Survey for stating the equivalents in yards of distances known in metres, and it has been so employed, as stated in the respective places, in various lists of geographical positions and tables for projections in the Coast Survey Reports, from 1851 to 1868. Since that time it has been deemed advisable to employ the value obtained by Clarke, viz., 39·3704 inches. The conversion is readily made with very sufficient accuracy, by increasing the distances in yards by their 1 : 20,000th part. A table of equivalents is given below (Annex II).

It is not practicable to attain greater precision in comparison until after the completion of the new international metres now in course of construction at the International Bureau of Weights and Measures in Paris. When the construction of these shall have been perfected, and when they shall have been thoroughly intercompared, it will be useful once more to attempt to arrive at a closer comparison of the yard and metre than we now possess.

In order to make such a comparison with the least number of successive operations, I have devised the following scheme: Divide a yard into four parts by successive bisections; dividing again the sum of three of these parts into eight equal parts by successive bisections, one of these eighths added to the yard will give the length of the metre with a degree of precision readily within the reach of the comparator; that is to say, the length will be 39·375 inches. Two bars correspondingly divided have been prepared for this purpose, and intercomparison is in progress. Very respectfully, J. E. HILGARD,

Assistant Coast and Geodetic Survey
in charge of Verification of Standards.

To CARLILE P. PATTERSON, *Superintendent.*

ANNEX I.

An act to authorize the use of the metric system of weights and measures.

Be it enacted by the Senate and House of Representatives of the United States in Congress assembled, That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system, and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. *And be it further enacted*, That the tables in the schedule heretofore annexed shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining and expressing in customary weights and measures the weights and measures of the metric system.

Measures of Length.

Metric denominations and values.		Equivalents in denominations in use.	
Myriametre	10,000 metres.	6·2137	miles.
Kilometre	1,000 metres.	0·62137	mile, or 3280 feet 10 inches.
Hectometre	100 metres.	328	feet 1 inch.
Dekametre	10 metres.	393·7	inches.
Metre	1 metre.	39·37	inches.
Decimetre	1-10 of a metre.	3·937	inches.
Centimetre	1-100 of a metre.	0·3937	inch.
Millimetre	1-1000 of a metre.	0·0394	inch.

Measures of Surface.

Metric denominations and values.		Equivalents in denominations in use.	
Hectare	10,000 square metres.	2·471	acres.
Are	100 square metres.	119·6	square yards.
Centare	1 square metre.	1550	square inches.

Measures of Capacity.

Metric denominations and values.			Equivalents in denominations in use.	
Names.	No. of litres.	Cubic measure.	Dry measure.	Liquid or wine measure.
Kilolitre or stere	1000	1 cubic metre	1308 cubic yards	264·17 gallons.
Hectolitre	100	1-10 of a cubic metre	2 bush. and 3·35 pecks	26·417 gallons.
Dekalitre	10	10 cubic decimetres	9·08 quarts	2·6417 gallons.
Litre	1	1 cubic decimetre	0·908 quart	1·0567 quarts.
Decilitre	1-10	1-10 of a cubic decimetre	6·1022 cubic inches	0·845 gill.
Centilitre	1-100	10 cubic centimetres	0·6102 cubic inch	0·338 fluid ounce.
Millilitre	1-1000	1 cubic centimetre	0·061 cubic inch	0·27 fluid dram.

Weights.

Metric denominations and values.			Equivalents in denominations in use.	
Names.	No. of grams.	Weight of what quantity of water at maximum density.	Avoirdupois weight.	
Millier or tonneau	1,000,000	1 cubic metre	2204·6	pounds.
Quintal	100,000	1 hectolitre	220·46	pounds.
Myriagram	10,000	10 litres	22·046	pounds.
Kilogram or kilo	1,000	1 litre	2·2046	pounds.
Hectogram	100	1 decilitre	3·5274	ounces.
Dekagram	10	10 cubic centimetres	0·3527	ounce.
Gram	1	1 cubic centimetre	15·432	grains.
Decigram	1-10	1-10 of a cubic centimetre	1·5432	grains.
Centigram	1-100	10 cubic millimetres	0·1543	grain.
Milligram	1-1000	1 cubic millimetre	0·0154	grain.

Approved July 27, 1866.

ANNEX II.

COMPARISON OF YARDS AND METRES.

1 metre = 1·093623 yards = 39·37043 inches.

Metres.	Yards.	Yards.	Metres.
1	1·093623	1	0·914392
2	2·1 7246	2	1·828784
3	3·280869	3	2·743175
4	4·374492	4	3·657567
5	5·468116	5	4·571959
6	6·561739	6	5·486351
7	7·655362	7	6·400743
8	8·748985	8	7·315134
9	9·842608	9	8·229526

Franklin Institute.

HALL OF THE INSTITUTE, Jan. 21st, 1880.

The stated meeting was called to order at 8 o'clock P.M., the President, Mr. William P. Tatham, in the chair.

There were present 198 members and 68 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that ten persons were elected members of the Institute at their last meeting.

The Secretary reported the following donations to the Library:

Report of Proceedings of the Second International Meteorological Congress at Rome. 1879.
From the Meteorolog. Com. Royal Society.

Annual Report of the Comptroller of Currency. Dec. 1, 1879.
From J. J. Knox.

On the Coincidence of the Bright Lines of the Oxygen Spectrum with Bright Lines in the Solar Spectrum. By Henry Draper.

On Photographing the Spectra of the Stars and Planets. By Henry Draper.
From the Author.

Third Annual Report of the Department of Public Works of Chicago for 1878.
From D. S. Mead.

Annual Report of the Provost of the Peabody Institute of Baltimore for 1879.
From the Institute.

Annual Report of the Secretary of War for 1879.
From the War Department.

Annual Report of New York Meteorolog. Observatory for 1878.
From D. Draper.

Journal of the Royal Geographical Society, Vol. 48.
From the Society.

Beiträge zur Anatomie u. Physiologie der Pulmonaten.
From Dr. Otto Nusslin.

Programm der Grossherzoglich Badischen Polytechnischen Schule zu Karlsruhe.
From the School.

List of Vertebrated Animals now or lately Living in the Gardens of the Zoological Society of London. Seventh Edition. 1879.
From the Society.

Memoirs of the Geolog. Survey of India. Vol. 16, Part 1.

Memoirs of the Geolog. Survey of India. Palæontologia Indica. Ser. 2, Vol. 1, Part 4. Ser. 13, Part 1.
From the Geological Survey of India.

Received from Robert Grimshaw, Ph. D., 1445 Circulars, 824 unbound and 21 bound volumes of Catalogues, etc., of French and American Exhibitions.

Transactions of the American Institute of Mining Engineers. Vol. 7.
From the Institute.

Report of the Commissioner of Fish and Fisheries for 1877.
From the Smithsonian Institution.

Report of the Fourteenth Industrial Exhibition of the Mechanics' Institute of San Francisco for 1879.
From the Institute.

Exposition Universelle de Paris Catalogue Illustré de Machines pour Travailler le Bois. Par A. Ransome & Co. 1878.

Catalogue of Disston & Sons File Company, Philadelphia. 1876.
From R. Grimshaw, Ph.D.

Erster Jahresbericht der Geographischen Gesellschaft zu Hannover. 1879.
From the Society.

Geolog. Survey of Japan. Reports of Progress for 1878 and 1879. By B. S. Lyman.
From the Survey, Tokei.

Fourth Annual Report of the American Railway Master Mechanics' Association. 1871.
From the Association

American Ephemeris and Nautical Almanac for 1882. First Edition.

Narrative of the Second Arctic Expedition made by C. F. Hall. By J. E. Nourse.
From the Navy Department.

The Queenslander. An Australian Weekly. 1877—1879.
From Hector Orr.

The President read the following

ANNUAL REPORT OF THE BOARD OF MANAGERS.

The Board of Managers of the Franklin Institute respectfully submit to the Annual Meeting the following report of the transactions of the Institute during the year 1879:

Members.—During the year 125 persons were elected members of the Institute, 33 have resigned, and there are now on our books the names of 1434 members in good standing. Of those members whose loss by death we have been called upon to notice particularly the Board will mention Mr. J. B. Knight, Secretary; Mr. Charles S. Close, Vice-President; Dr. Isaac Hayes, Mr. Henry C. Carey, Mr. Wm. Adamson and Mr. John Wise.

Treasurers' Report.—The following is a summary of the Treasurer's report for the year 1879:

Receipts.		
Balance on hand Jan. 1, 1879,	$3,018.17	
Bloomfield Moore Trust Fund,	10,000.00	
Investments paid off,	8,000.00	
Receipts from all other sources,	11,755.45	
		$32,773.62
Payments.		
Five per cent. Building Loan, and Interest,	$1,121.25	
Re-invested,	17,958.75	
All other payments,	12,287.77	
Balance on hand Dec. 31, 1879,	1,405.85	
		$32,773.62

This statement shows a reduction in the money and investments of the Institute by the operations of the year of $532.32. If, however, we take into account the improvement of the Library and building, the balance would be the other way.

Journal.—The JOURNAL of the Institute has continued under the direction of the Committee on Publication and the Secretary. This system, while it requires the unpaid-for labors of the members of the Committee, has otherwise worked well. During the past year, owing, as far as we know, to the excellence of the matter published, exchanges of the JOURNAL have been requested by both national and local scientific bodies in Europe, and the exchange list now embraces 161 scientific and technological periodicals, which are deposited in the Library for the use of members, and are duly bound for reference hereafter.

Drawing School.—The attendance upon the Drawing School has been larger than usual.

In the early part of last summer the Board arranged with the Pennsylvania Museum and School of Industrial Art to combine their efforts in this direction, and consequently the drawing school of that organization is now in satisfactory operation, under our roof, to mutual advantage.

To obtain the room necessary for this purpose, the models have been distributed over the building where they can be seen to most advantage, and the Cabinet of Minerals has been deposited with the Academy of Natural Sciences, subject to recall at any time.

In making this arrangement the Board was aware that the Franklin Institute contributed a larger proportion to the common effort than its proportion of the benefits resulting therefrom. But the Managers looked to the objects for which the Institute was erected, and desired to promote them in every way for the benefit of the citizens of Philadelphia.

The result proves the advantages of combination, and it may be profitably studied by other organizations whose special objects are embraced in our own.

Library.—The improvements of the Library have been continued during the year. The report of the Committee on the Library will present the details. During the last five years that committee has made a sustained effort, with the sums placed at its disposal, to bring up the Library to a condition adequate to satisfy the wants of the members; and although this state has not yet been reached, the Board esteem the progress already made as a matter of congratulation. The generous donation of $10,000, which established the Bloomfield Moore trust, will ensure the result desired.

Lectures.—During the early part of the year Prof. Elihu Thomson delivered five lectures on physical subjects, Prof. Frazer eight lectures on chemistry, Mr. J. B. Knight one lecture on ice, and Mr. D. S. Holman two lectures on life and motion as illustrated by the microscope.

In the arrangement of the courses this winter the same general plan has been adopted as heretofore, but in addition to the purely technical lectures, some upon topics of much general interest have been introduced.

In November Mr. Holman opened the course with a repetition of his lecture on motion and life, followed by four lectures by Prof. John M. Child on astronomical subjects. Mr. John Haug has also given a course of five lectures on mechanics, Dr. W. H. Greene three lectures on sugars and starches, bread-making and fermentation, Mr. C.

A. Ashburner, of the Pennsylvania Geological Survey, two lectures on petroleum, and Prof. Frazer is at the present time giving a very instructive course of eight lectures on modern chemistry, in which the new Hofmann apparatus, purchased for the Institute, is being used for the illustration, to great advantage.

In conclusion, the Board of Managers desire to press upon the members their duty of adding to the membership, until it shall bear something like the same proportion to the population of Philadelphia as existed when the Institute was first founded. No qualifications are required beyond a good moral character and nomination by members. If the new comer be a learner merely, he will have all the advantages of instruction the Institute can offer, which are greater than can be had elsewhere for the same cost. If he be a teacher, he may still find much to learn, with assistance for original research. Should he have no need or desire to benefit himself, he may find satisfaction in contributing a trifle for the benefit of others.

By order of the Board,

W. P. TATHAM, *President.*

Philadelphia, Jan. 21, 1880.

THE LIBRARY.

To the Franklin Institute:

The Committee on the Library respectfully report that there has been added to the Library during the past year:

Bound volumes, . . .		1254
Unbound " . . .		1836
Total, . . .	Vols.	3090

The number of bound volumes in the Library on the 31st day of December, 1879, was 14,813.

Valuable donations have been received from the different Bureaus of the United States Government, from Great Britain and from France. These donations, which have been properly acknowledged, have enabled the committee to complete the patent reports of the above mentioned governments, as also to add to the Library many maps and charts of great interest.

Ninety-eight *duplicate* volumes have been exchanged with other libraries, and with individuals, for books which were desirable for the Library of the Institute.

Thirty-three serial publications have been completed. Some of these are standard representatives of the progress of science and art in different departments represented by them, and in some cases the missing numbers were difficult to obtain.

Many models of historical interest from the old model-room have been distributed over the cases in the Library; these models, when properly labelled, will contribute to the interest of members of the Institute and to visitors.

There has been an increased interest in the Library shown by members, and the yearly increasing value ot the collection of works representing all the departments of science and the arts offers an inducement to a larger number than is now enrolled on the list of members of the Institute to avail themselves of its privileges.

Respectfully submitted.

CHAS. BULLOCK, *Chairman of Com. on Library.*

January 13, 1880.

The Representative of the Institute in the Pennsylvania Museum and School of Industrial Art presented the following report:

The progress reported last year in this highly deserving institution we are happy to say has continued, and we trust the day is not far distant when its usefulness as a great art school will be acknowledged by all, and the wisdom of its foundation seen.

Under the able direction of a Curator, appointed early in the year, the arrangement of the various collections has been completed, and a system of registration of objects owned by or loaned to the Museum adopted, from which a catalogue can be made at any time.

In addition to the fine collection of medals and coins deposited by the American Philosophical Society, the Antiquarian Society of Philadelphia and the Library Company, Mr. Hockley has loaned to the Museum a very complete set of medals of the different Popes, etc., which are of great value from their historical connection and interest as works of art. It is to be hoped that the example set may be very generally followed, and many things deposited by their owners from time to time which will prove of great value to the student of art, and at the same time enhance the attractiveness of the display.

Early in the year the Grant collection of testimonials, deposited by Mr. George W. Childs, was loaned to the Pittsburg Library Exhibition, and still later it was sent to Chicago, with a representative collection from the Museum, for the Industrial Exhibition held in that city. By similar loans of works of art, under proper restrictions, it is hoped that not only will much good be done, but the general public be made aware of the importance of the collections, and extend to it more liberal aid.

The fine display of mineral and metallurgical specimens collected by the American Institute of Mining Engineers during the time of the Centennial, and which has been for some time stored in Memorial Hall, was in March last formally transferred to the Trustees, and early in June the collection was arranged and opened to the public. The value of this collection and its importance is so great as to merit its being classed as the most important event of the year.

A radical change has been made in the method of conducting the schools, and with the fall term they have been no longer free, but are carried on in the same rooms as our own, and upon the same terms. A gratifying increase in the number of the pupils attending is also to be noticed. The Ladies' Art Needlework Department has been transferred to an independent organization, and much interest being taken in the school, the change has proved a beneficial one.

Our late esteemed Secretary worked hard for the success of the institution that I have the honor to represent, and his death, in March last, has been severely felt by all connected with the Museum. Chairman of the Committee on Mechanic Arts, Mr. Knight, was untiring in all that would promote its welfare, while his training as an engineer admirably fitted him for this position, and the Museum was indeed fortunate in having his place so well filled by Mr. Frederick Graff.

ISAAC NORRIS, M.D.

January 21, 1880.

Mr. Cyrus Chambers, Jr., explained by photographic diagrams the construction of his new "Positive Register" for recording revolutions, and the machine was exhibited in operation, counting up to 5000 a minute with the greatest accuracy.

Hyzer and Lewellen's Portable Enamelling Furnace was shown, and some remarks were made upon its construction, the method of baking, etc., by Mr. Charles H. Roney. Specimens of the porcelain and tiles from the furnace were exhibited.

The Secretary's report included a paper giving some particulars of the manufacture and properties of Kerite, an invention of Mr. A. Goodyear Day. A fine exhibit of cables, of different sizes; tubing and insulated wire, were upon the table. The Saybolt Electrical Tester, for petroleum oils, was explained, and a photograph of the instrument thrown upon the screen. Attention was also called to Noyes' Dictionary Holder, and the "Beardmore Steam and Water Packing," composed of rubber and wire cloth, made at Akron, Ohio.

Mr. A. E. Outerbridge, Jr., of the United States Mint, described his visit to Menlo Park, and made some remarks on Edison's Electric Light. A lamp was exhibited, and photographs of the generator, etc., shown. The subject was discussed by Profs. Rogers and Thomson, Addison B. Burk and others.*

The tellers of the election held this day presented their report, and in accordance therewith the President declared the following members elected as officers and managers:

President, William P. Tatham.

Vice-Presidents, Henry Cartwright and Charles Bullock.

Secretary, Dr. Isaac Norris.

Treasurer, Frederick Fraley.

Managers to serve three years, C. H. Banes, C. Chabot, Prof. Persifor Frazer, W. Helme, Prof. E. J. Houston, E. Lewis, S. Sartain, J. J. Weaver.

Auditor, W. A. Cheyney.

Representative in the Pennsylvania Museum, Dr. Isaac Norris.

The tellers of the election not being able to agree whether certain proxies of members presented to them should be counted, Mr. J. J. Weaver moved that they be not received.

Dr. Rogers moved as an amendment that the whole subject be referred to a committee for a report, which was carried, and Messrs. Weaver, Rogers and McKean were named as the committee.

On motion, the following addition to the By-Laws, Article VIII, was unanimously agreed to: "In case of a vacancy in the office of Treasurer, it shall be the duty of the Board of Managers to appoint a person to fill the office *pro tempore*."

On motion, the meeting adjourned.

ISAAC NORRIS, M.D., *Secretary*.

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* A full report will appear in the next number of the JOURNAL.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE GOODWIN MOWING MACHINE AND THE NEW MECHANICAL MOVEMENTS EMBODIED THEREIN.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, December 31st, 1877.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination the Goodwin Mowing Machine and the new mechanical movements embodied therein, report that this machine consists of a right-angled triangular cast iron framing, hanging at its short side upon and swinging about an axle which revolves in self-adjusting roller boxes, encased to form oil receptacles and be protected from dirt. The driving wheels running loose upon this axle are below the usual size of such wheels, and have upon their peripheries numerous lugs or spuds to secure traction.

Motion is communicated from these wheels to the axle by means of internal ratchets, upon the inside of their rims, which engage with pawls upon the end of the arms firmly secured to the axle, whereby the forward motion only of the wheels is communicated to the axle, and through it to the operating parts of the machine, with but little loss of motion, an advantage that will be more apparent hereafter.

To the forward and acute angle of the main frame is secured the cutter bar, extending laterally just in front of the off driving wheel, and is joined to the angular frame by a peculiar hinge and lever, whereby the cutter bar may assume any angle from 45° below to 90° above the horizon, and be tilted so as to throw the guards down to the ground for the purpose of catching and raising down and lodged grass, or be thrown up to clear stones and rough ground.

The pole is attached to the main frame by a hinge, located back of and above the axle, whereby the frame and pole may take any required position relative to each other, so that in passing over undulating ground the horses may be on a raise and the cutter bar in a hollow, or *vice versa*.

The seat for the driver is secured to the pole upon a steel spring, fastened to the foot-board by a loose bolt and rubber, acting in such a manner as to allow a lateral as well as vertical spring motion, thus relieving the driver of the sudden side lurches as well as the vertical jar.

The weight of the driver is thrown behind the jointed connection of the pole and frame, thus almost balancing the weight of the pole, and relieving the horses' necks from any unnecessary strain.

The jointed connection of the pole and framing, being back of the axle carrying the frame, and adjustable, the combined weight of driver, pole and whiffletrees are made to almost balance on the axle the main frame of the machine with its attachments, so that their combined weight is thrown upon the driving wheels, and the sliding shoes relieved from carrying any great weight, whereby lightness of draft and great traction is secured.

The near driving wheel is made about one-half inch smaller in diameter than the off one, thereby giving it a tendency to make a greater number of revolutions than the larger one, and consequently throwing the burden of the propelling force upon it, which counterbalances the resistance to the cutter bar in the grass, thus almost entirely avoiding the tendency to side draft. So nicely are these forces, together with the weight of the driver and pole, balanced, that the latter may be taken from the yoke and the machine continue its work almost as steadily as before.

The draft link, connecting the whiffletree to the frame of the machine, is secured to the frame by an arm projecting below the axle, whereby a lifting tendency, in proportion to the draft or resistance at the cutter bar, is imparted to the forward end of the frame, and relieves it of the downward thrust at the cutter bar and the upward thrust at the axle, whereby the draft is lessened and the traction increased.

The power necessary to hold back, or to back the machine, is applied at the yoke and through the pole to the main frame; but, as the pole is secured to the frame by the hinge located above the axle, the power necessary to back the machine raises the forward end of the main frame together with the cutter bar, thus clearing all from the ground in backing, and enabling the machine to be backed over the cut grass without catching it up or clogging the machine.

The cutter bar, with the forward end of the main frame, may be set and held at any convenient and desired distance or angle from the ground, so as to cut a higher or lower stubble, or raised to clear obstructions, independent of the tilting of the guards, whereby the down grass is raised.

The guards are secured to the cutter bar at an angle with its surface, so that when the grass is cut and passes over the bar it has an inclined plane to slide upon, whereby much of the crowding forward of the cut grass is prevented—a serious difficulty, we believe, in all other machines when cutting "lodged grass."

When it is desired to move the machine from place to place, the cutter bar is raised to a perpendicular position, and secured by a notch in the adjusting lever, and the main frame hooked to the pole, when the flexible parts of the machine become rigid and entirely clear of the ground, thus enabling the machine to be driven, as a sulky, from place to place. All of these changes in the machine are easily and quickly made by the operator without leaving his seat or stopping his team, and render the machine exceedingly convenient for mowing around stumps, rocks and over rough ground. The *reciprocating motion* for the sickle is obtained by what the inventor calls a "*reciprocating screw*," a mechanical term, the correctness of which was at first seriously questioned by your committee, but, upon a closer analysis of the construction of the device, we are compelled to accept this term as a correct one.

This "*new mechanical movement*," as the inventor also calls it, is a device that is very simple in its construction and operation, and seems particularly adapted to the requirements of a mowing machine. The female or nut portion of this movement consists of two discs bolted together, the inner surfaces of which are made with radiating angles or corrugations, the number of which correspond to the number of vibrations desired to be obtained from one revolution. The faces of these angles have the shape peculiar to that of the sides of the thread of a screw, that is, the angle increasing as the diameter diminishes. Both sides of the angular projections would be exactly represented by sections of a many threaded and right- and left-handed screw.

These discs are secured together by projecting flanges, thus forming a casing, and arranged relative to each other, so as to leave the points of the screw sections inside some distance apart, between which works the male or "bolt" portion of the screw.

This "bolt" consists of a disc having similar corrugations or sections of right- and left-handed screws upon either side, corresponding to the nut or casing in pitch and number of threads, and is secured to a sleeve, working over the shaft and through one of said discs, whereby its reciprocating motion may be communicated outside of the casing.

This casing is secured rigidly to the driving shaft and rotates with it.

The internal disc or bolt has upon its sleeve trunions, working in the lever which moves the sickle bar.

As the nut or casing revolves, the bolt or disc is unscrewed from the right-hand thread of one side into the left-hand thread of the other side.

When it has reached the full length of this section it meets the right-handed thread upon the other disc or nut, and is forced back, entering the left thread upon the first disc; thus a constant reciprocating motion is obtained, the number of throws to one revolution depending upon the number of threads in the screw.

In the case before us thirty-eight strokes are obtained by one revolution of the main wheels, without the use of spur gears for getting up the quick rotary motion, mitre or bevel gears for turning the motion at right angles, as is required in mowing machines, and the crank and pitman for converting the rotary motion thus obtained into reciprocating.

The connection between the lever and the sickle bar is a link, with ball and socket joints, and allows of the free adaptation of the frame and cutter bar to the undulations of the ground.

From the fact that the sickle receives its motion from sections of screws, the motion is uniform throughout the whole length of the stroke, thus presenting a uniform and almost continuous cutting motion to the grass, whereby the cutting is done without allowing time for the grass to bunch in the guards, as is the case in machines where the sickle is operated by a crank.

The abrupt reversing of the motion of the reciprocating parts in this machine at first presented itself to us as a serious difficulty in this movement, but upon a close examination it appears that the vibrating disc or bolt cushions the air between it and the nut or case, and their surfaces so nicely coinciding with each other, and being of so extended an area, the momentum is taken up and overcome in a very great degree by this air cushion.

The casing of this movement, being fitted together oil-tight, becomes an oil receptacle, into which a considerable quantity of oil may be placed, when by its revolution every part of the working surfaces are submerged in oil.

The wearing surfaces are so large that the oil appears to prevent the actual contact of the metals.

One movement, on examination after use in cutting many acres of grass and millet, showed but little signs of wear; that seen was scarcely perceptible, the sand marks still being on the cast wearing surfaces.

This condition of things is evidence of but little friction in this movement.

FIELD TESTS.

Your committee made quite a number of field tests, in some of which five other machines of different manufacture, representing the leading machines of the country, were tested in comparison with the Goodwin reciprocating screw machine.

All the machines were good samples of their kind, and were put in good order by one man, who was employed for the purpose, and believed to be disinterested and impartial.

The same team was used for each machine during each test, and each machine operated by, we believe, impartial and experienced persons throughout each set of trials.

The instrument used in the early field tests was one of Fairbanks' non-recording dynamometers, which proved unsatisfactory on account of the great discrepancies in the readings by different persons, when it was resolved that five persons should record the draft as indicated, and the average of the whole be taken as correct.

This also proving unsatisfactory, both to your committee and to the parties in interest, a self-recording dynamometer was invented and constructed expressly for the purpose, recording on a continuous moving paper all the variations of draft and working, with all the delicacy and precision desired.

The field tests were numerous and varied, being made over great varieties of ground, from the well-kept lawn to rocky, rolling land; from heavy swamp grass to dry hillsides, covered with last year's dead grass and the growth of the present year; from the short matted park grass to millet 5 feet high, through ditches and over rocks into washed soils.

Terraces at an angle of 45° were mowed, both from the top downward and from the bottom upward.

Altogether, the machines were, in the opinion of your committee, put to a more severe test, and a greater variety of work, than they would encounter in many years' use on the farm.

The mechanical tests were:

1st. To test the traction of the wheels upon the ground with their ordinary load.

2d. The power applied in draft to overcome an increasing resistance upon the sickle bar.

3d. The power lost by friction in converting "slow rotary" into "quick reciprocating" motion under a constant resistance, also under an intermitting resistance.

4th. The draft power required to cut off between the cutters and guards various sizes and kinds of woods.

5th. The weight thrown upon the yoke, or horses' necks, under varying draft strains.

6th. To get an exact diagram of the movement of the sickle as the machine passes over the ground.

To ascertain the above facts, strains and resistances, special apparatus was constructed.

One test consisted of a given weight, moving through a given space, suspended from the driving wheels, producing a given motion to the sickle bar, under constant and under intermitting resistances, for which a specially devised and constructed instrument was used.

The non-recording dynamometer and spring balances were tested each by the other, and by weights, and were found to correspond very closely throughout the whole scale.

The recording dynamometer required considerable force to overcome the friction of the recording device which tended to steady its movements while this resistance was counted and recorded in the log.

To ascertain the precise movements of the sickle in cutting grass, as the machine traveled over the ground, a recording instrument was attached to one of the sickle sections, recording its movements on paper as the machine moved in its usual course over the ground.

These diagrams will be found with the other records herewith submitted.

All the machines were tested by the same instruments, taken immediately from one machine to the other without change.

To give in this report all the data and figures obtained from field and mechanical tests would render it voluminous, and a mass of unintelligible notes and figures, incomprehensible to the general reader.

Your committee has therefore deemed it best to submit herewith a copy of the log,* and give only the result in percentages and degrees, and invite those desiring more of the details to glean them from the records themselves.

From the data and facts obtained, and our observation and use of the various machines, your committee have arrived at the following conclusions relative to the *Goodwin Mowing Machine:*

1st. For ease and comfort to the driver it stands first.

2d. For convenience of manipulation in the field, cutting over and around obstructions, it stands first.

3d. For cutting over uneven or undulating ground, over ditches and steep terraces, it stands first.

4th. For mowing wet swampy bottoms, through swamp and wet grass, it stands first.

5th. For raising and cutting down grass, for cutting close and even stubble of uniform length for lawn or parks, it stands first

6th. For cutting high, heavy and lodged grass, it stands first.

7th. For power to cut large weeds of woody growth, bushes, etc., it excels all others tested by about one hundred per cent.

8th. It is the only machine examined, or known to your committee, that will raise its cutter bar and framing, and clear the cut grass in backing from its cut.

9th. For the absence of side draft it stands first. It is the only machine known to us that is free from it.

10th. It is the only machine known to us that is free from unnecessary weight on the yoke, or horses' necks, under varying draft strains.

11th. For lightness of draft while running all its parts, without cutting, it stands first.

12th. For durability of wearing parts it stands first.

13th. For economy of construction it stands first.

14th. In point of noise in running it stands third.

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* A brief summary of the log is herewith appended.

THE MECHANICAL MOVEMENT AS A DEVICE FOR CONVERTING SLOW ROTARY INTO QUICK RECIPROCATING MOTION, OF UNIFORM VELOCITY.

For the application of this device to various uses your committee are of the opinion that its application is limited to those uses where but light parts are to be reciprocated and the source of power slow and rotary, and a uniform motion is desired through the whole length of the stroke.

The abrupt cessation of the motion in one direction, and its instant starting at full velocity in another, renders it unfit, in our opinion, for general use or for heavy moving parts.

Its embodiment in a mowing machine seemed to us to be a most happy application of this new mechanical movement.

The requirements of the movements in mowing machine sickles are arbitrary when the best results are to be obtained, and this device seems to fill them most admirably, converting the slow rotary motion of the driving wheels into quick reciprocations in a direction parallel to the axis of rotation.

Its uniform motion keeps the sickle cutting the grass with the minimum resistance or quantity of grass at a time, and prevents "bunching" of the grass between the guards, a serious objection to the crank movement, bunching taking place during the time the crank is passing the centres.

1st. For simplicity this movement stands first.

2d. For durability it stands first.

3d. For economy of power it stands first, one test showing that the ordinary crank and gearing required over one hundred per cent. more power than this movement did to do the same work.

Considering the many difficulties to be overcome in adapting machinery to the varied conditions under which agricultural machinery generally is required to work, and especially harvesting machines, and remembering how thoroughly and practically the inventor of this machine has accomplished this, your committee are of the opinion that no award at the disposal of the Institute is too great for such a victory.

We therefore recommend that the Franklin Institute award to Wm. Farr Goodwin "THE ELLIOTT CRESSON GOLD MEDAL" for his mowing machine, and the SCOTT'S LEGACY PREMIUM and MEDAL for the new mechanical movement contained therein.

Respectfully submitted.

CYRUS CHAMBERS, JR.
W. BARNET LE VAN.

Approved Feb. 6th, 1878.

MOWING MACHINE TEST.

Brief Summary from Log Book, for convenience of Reference.

First practical field test. Horace J. Smith's field. Lowest average drafts by the non-recording dynamometer, one person, only, calling the figures.

Buckeye Machine.

Draft, empty, down grade, .	80·3	pounds.	
“ “ up “ .	125·	“	
“ cutting high stubble, .	164·74	“	
“ “ low “ .	191·10	“	

Clogged four times in cutting two swaths. No. 1.

Worm-wheel and Screw Machine.

Draft, empty, down grade, .	118·75	pounds.	
“ “ up “ .			
“ cutting, down “ . .	209·82	“	

Champion Haymaker Machine.

Draft, empty, down grade, .	91·78	pounds.	
“ “ up “ .	123·68	“	
“ cutting, down “ . .	245·45	“	No. 4.

Little Giant.

Draft, empty, down grade, .	105·	pounds.	
“ “ up “ .	117·	“	
“ cutting, down “ . .	204·46	“	No. 2.

Goodwin's Reciprocating Screw.

Draft, empty, down grade, .	127·77	pounds.	
“ “ up “ . .	172·91	“	
“ cutting, down “ . .	205·88	“	No. 3.

Second public field test. Dr. Heenan's field. Non-recording dynamometer; five persons recording, and the average of all taken as correct.

Reciprocating Screw.

Out of gear,	75	pounds.	
In gear, running empty,	87	“	
“ cutting fine grass,	162·5	“	No. 1.

Champion Haymaker.

Out of gear,	80	pounds.	
In gear, running empty,	104	“	
“ cutting, 2 drags,	185	“	No. 2.

Buckeye.

Out of gear,	83	pounds.	
In gear, running empty,	103	“	
“ cutting,	191	“	No. 3.

Worm-wheel and Screw.

Out of gear,	88	pounds.	
In gear, running empty,	118	“	
“ cutting,	191	“	No. 4.

Third public field test. George's Hill. Self-recording dynamometer; average taken from the card.

Worm-wheel and Screw Machine.

Not cutting, but in gear, average,	154	pounds.	
Cutting fine park grass (half dead),	215	“	No. 4.

Champion Haymaker.

Not cutting, but in gear,	180	pounds.	
Cutting same grass,	246	“	No. 5.

Buckeye.

Not cutting, but in gear,	140	pounds.	
Cutting same grass,	211	“	No. 3.

Goodwin's Reciprocating Screw, New Pattern.

Not cutting, but in gear,	189	pounds.	
Cutting usual height and same as others, and in same grass,	210	“	
Cutting $\frac{3}{4}$ inch lower,	247	“	No. 2.

Goodwin Reciprocating Screw, Old Pattern.

Not cutting, but in gear,	154	pounds.	
Cutting same grass,	208	“	No. 1.

Friction test under normal load. Public test on Horace Smith's lawn.

Buckeye slides at 750 pounds with both wheels. No. 3.

Goodwin's Reciprocating Screw slides at 500 pounds with one wheel, with 250 pounds resistance; but dynamometer would not measure the draft strain at the cutter bar for both wheels, it being limited to 1000 pounds. No. 1.

Champion Haymaker—both wheels slide at 650 pounds. No. 4.

Worm-wheel and Screw—both wheels slide at 800 pounds. No. 2.

Butyric Ferment in the Coal Period.—Van Tieghem has studied some of the vegetable fossils in the Belgian coal, for the sake of comparing the changes which they have undergone, with those which take place at the present day. If fragments of the young roots of yew or cypress are left for some time covered with water, the *Bacillus amylobacter* is developed, attacks most of the tissues and completely dissolves the cellular membranes. In the bark, all the ordinary parenchyma, then the layers of cellular tissue, and finally the endoderm, gradually disappear, only leaving at the surface the summits of the epidermic cells which form the cuticle. In the central cylinder the root-producing layer and the conjunctive tissue are destroyed, only leaving the central band of vessels. The cellulose is decomposed as fast as it dissolves, and undergoes the butyric fermentation. At the same time the amylobacter leaves visible and direct traces of its development. The same progress in the destruction of the tissues is observed in the coal, leaving as a final result only the cuticle and the vessels. There are also the same visible and direct traces of the development of the amylobacter in the interior. We may, therefore, conclude that in the marshes of the coal epoch, as well as in those of our own time, the same plants underwent, in the same portions of their tissues, the same dissolution by the same agent. Then, as now, the *Bacillus amylobacter* was the grand destroyer of vegetable organisms, and the butyric fermentation which it excites was displayed as one of the most general of all organic phenomena. Pasteur's investigations of this ferment find in these facts a new application, which will be fruitful in palæontology.—*Comptes Rendus.*

SAWS.*

By Robert Grimshaw, Ph.D.

[Continued from January issue.]

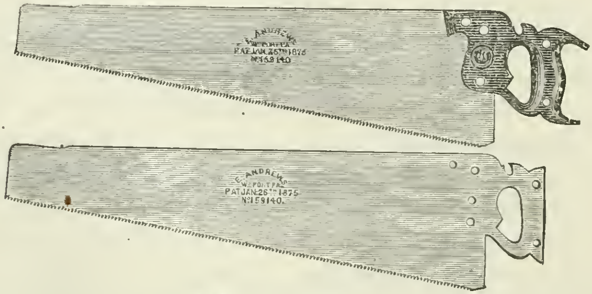
Class 4, free at one end, and "push cut" is perhaps the most numerous of all—including principally all the varieties of carpenters' hand saws, of both parallel and taper blades, with and without backs.

In general, the teeth are of equal size throughout the length; but there is in some varieties—notably the hand-rip-saw—an increase in the size of the teeth from point to heel, referred to at the close of the remarks on saw teeth. But this increase is not always regular and graduated, being sometimes a sudden step.

This class may be subdivided into (*a*) taper saws, without frames, and (*b*) parallel saws, with backs. The following table gives lengths, sizes and spaces of teeth, etc.:

	Name.	Length.	Gauge.	Points to inch.
Taper.	Hand,	26″	19	5 to 12
	Rip,	28″ to 30″	18	Heel, 3 to 5 Point, 6 to 8
	Panel,	14″ to 24″	22 to 20	8 to 12
	Compass,	10″ to 20″	16	——
	Keyhole,	7″ to 9″	21	——
Backed	Tenon,	6″ to 18″	22 to 20	11 to 15
	Miter,	20″ to 30″	20 to 19	10 to 11

The *rip, half rip, hand, broken space, panel* and *fine panel* are alike in general appearance. *Chest* saws are merely diminutive thereof.



Figs. 26 and 27.

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* Extracts from "Grimshaw on Saws." 160 pp. Royal 8vo. Philadelphia: Claxton, Remsen & Haffelfinger. 1880.

The blade is "taper" in order that it may be nearly equally stiff throughout; for ease in attachment of the handle, and to lighten it. This taper is either straight or curved.

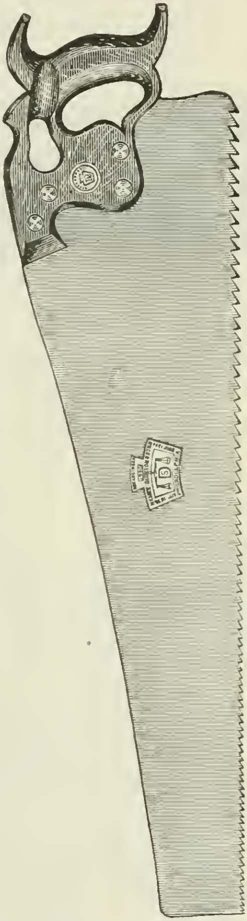


Fig. 28. "Skew Back" or Curved Taper Rip Saw.

The curved taper (Fig. 28) is claimed by the makers to somewhat lighten the saw, while lessening its liability to vibrate when drawn from a cut. The "increment" tooth of the rip saw is clearly shown in the figure.

Figs. 26 and 27 show a mode of strengthening the handle.

The *table* saw and the *compass,* or *lock* saws, differing only in size, and all used for curved line cutting, have narrow blades to permit their turning sharp corners.

The *keyhole* or *lock* saw is the narrowest. It should be made with a pull cut for the reasons stated, page 32.

Pruning saws are coarser, thicker and keener than those for dry wood. They are sometimes made with half moon or briar teeth for rapid execution.

The pond ice saw, generally supplied with a "tiller handle," is 7 to 8 inches wide at butt, 5 to 6 inches at point, and 9 to 10 gauge.

Hand saws for ice are about 24 inches long, gauges 16 and 18; teeth regular cross-cut pattern, ½ inch to 1 inch apart and deep, and with enormous set as this material clogs greatly.

The various *backed parallel bladed saws,* known as *tenon, sash, carcase* and *dovetail,* according to their uses, have thin and carefully hammered blades stiffened with a piece of metal sprung on. They are much employed for accurate work. Care should be taken not to spring the back by knocks.

The *smith's screw head saw* has a handle like a file and is used for cutting the slots in screw heads. It has a thick and hard blade.

The comb cutter's saw, sometimes called a "stadda," is double, the two blades being separated by packing, at any desired distance; one edge being slightly in advance of the other so as to enter a new cut, which the other finishes. Thus spacing and depth are preserved equal.

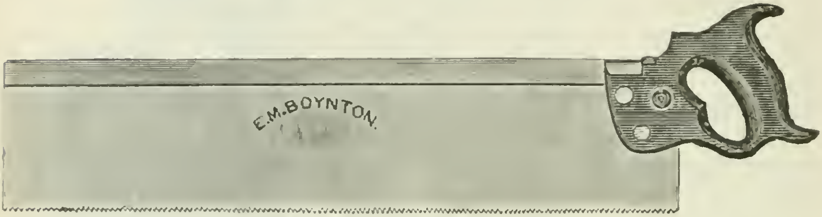
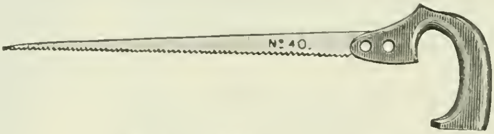


Fig. 29. Miter-box Saw.

See Fig. 30. Similar saws, on a larger scale, have been used for cutting microscope and air pump racks.



Keyhole and Lock Saw.

The increment tooth (see page 35) has these advantages for hand-saws: the fine teeth being used to start the cut and coarse ones to finish, a saw will work freely and easily. In hand-sawing the least

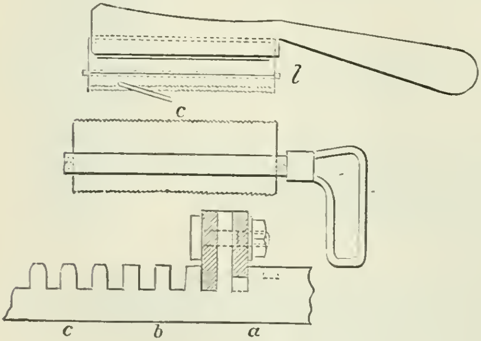


Fig. 30. Comb Cutting Saw.

Fig. 31. Adjustable-Backed Saw.

Fig. 32. Rack Cutting with Saws.

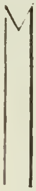
amount of power is employed at the beginning of the cut, but as the arm straightens at the elbow more force is used, and the coarser teeth allow it to be utilized because the space between the teeth do not clog as readily as the fine teeth do, and the fine teeth do not catch at the beginning of a cut as do coarse teeth.

The teeth of a hand saw should be so truly filed that on holding it up to the eye and looking along its edge lengthwise it should show a central groove down which a needle should slide freely. See Fig. A.

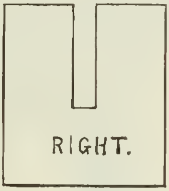
The cutting action should be such that the bottom of the kerf should present the appearance of Fig. B, and not that shown in Fig. C.

Fig. D shows the proper cutting action of the teeth.

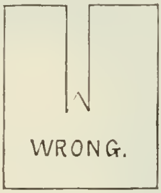
Saws free at one end and cutting on both strokes are comparatively rare. The M teeth hand saws and some butting saws mounted as drags, are all that we call to mind.



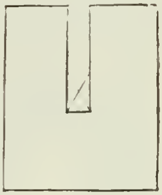
A



B



C



D

Class 6, strained in a sash, guided at both ends and cutting on both strokes, is a peculiar one. We call to mind but one representative—Robinson's horizontal veneer saw, shown at the Paris Exposition of 1878. Very peculiar inclined guides give the blade what would correspond to overhang on each stroke, so as to give lead both ways.

Class 7 is the *pit saw,* practically the single sash, unguided and worked by hand. The blade is from 5 to 8 feet long.

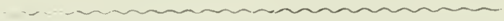
Class 8 includes the "cross-cut"—frequently written "× cut." They vary largely in general appearance and in disposition, but have always for their object the severing each fibre in two places.

They are made double as wide in the centre as at the ends—to stiffen the blade and to allow for the greater amount of wear in the centre. The "gains" or gullets in the centre are often made twice as deep as those at the ends, to save frequent "gumming."

In general there is one set of teeth termed "*scorers,*" which sever the fibres at the sides, and others called "cleaners," which remove the central core or ridge, and blow out the dust made by the others. Cross cutting is like scoring a "gain" in a plank with the edges of a chisel, and then with the flat edge removing the severed portions.

"Cleaner teeth," "clearers," or "plows," are made slightly shorter than the cutters with which they alternate.

In the "Twin Clipper" (see cuts) there are two M's, or four teeth to a section; one M, or two teeth, set each way. The maker claims that where there are but two teeth (or one M) in a section, both teeth set the same way, their tendency is to draw towards the point and first take to the side of the kerf and draw or spring the section over until it lets go when it reacts, cutting the sides of the kerf wavy, in this manner.



In this cross cut one pair of teeth is designed to counteract the spring of the other, keeping the section straight and unsprung. It is also claimed that when a section has but two teeth it cannot be as stiff as with four.

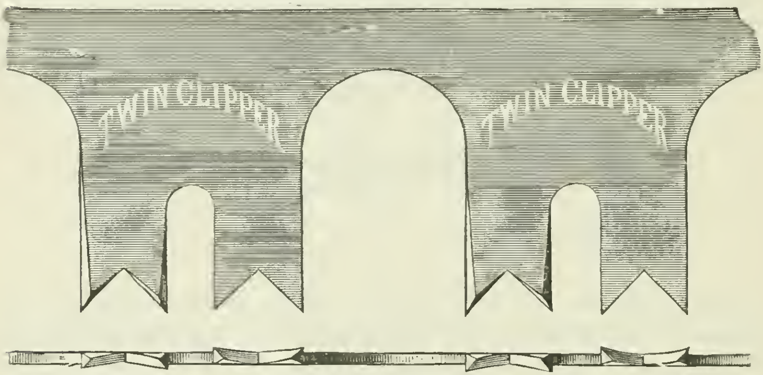


Fig. 33.

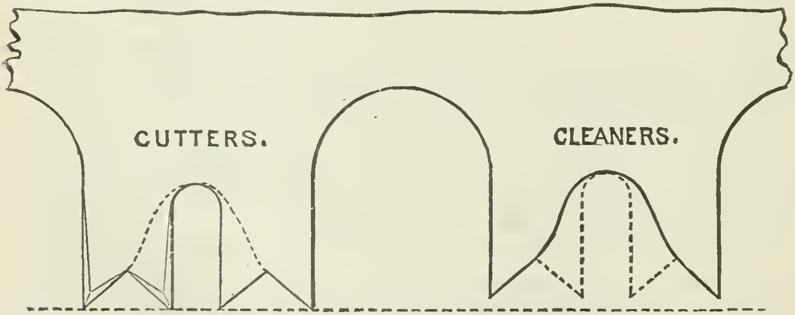


Fig. 34. Twin Clipper, showing Cleaners.

The cleaner teeth of the "Twin Clipper" (see Fig. 34) are made by simply cutting out the inside section of two teeth, as shown by the dotted lines in the cut—leaving two sets of cutting teeth or scorers between each pair of clearers, which are about $\frac{1}{32}$ inch below these last.

The teeth of solid cross cuts are difficult to keep of proper length and shape. The saw requires frequent gumming, and in this process is frequently broken or sprung and kinked, and then, unless hammered and straightened by a skilled hand, will be sure to give trouble by running hard and sticking in the log. The perforated cross cut avoids gumming, and the teeth are easily kept just right.

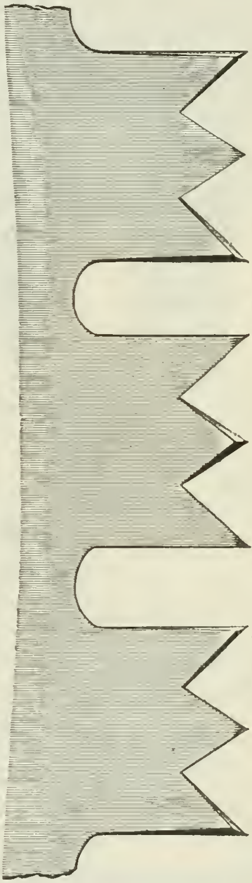


Fig. 35. Disstons' "Great American."

Fig. 35 shows part of a cross cut, in which the notch of each M is followed by perforations, as also are the larger gullets between the Ms and the Ws. Various styles of cross cuts are shown.

The Weight Strained Saw has only one application—to ice cutting. The blade is mounted vertically in a frame on a sled and is kept taut by a weight suspended in the water to the lower end. Arctic explorers use this saw for cutting their ships out of ice floes; and it has been used for heavy ice-cutting for commercial purposes.

The Spring Strained Saw, commonly known as the Gig, Jig, Fret or Scroll Saw, has a pull cut only; the return being effected by the same means that keeps it strained. It is light running and generally used for cutting out fine curved or scroll work; although of late years the band saw is superseding it for outside work.

Jig sawing really divides itself into two branches—sawing in irregular shapes on the outside of a piece of material, and the same process on the inside, known as fret work.

The short and readily detachable blades of the strained jig saw can be so quickly withdrawn from one cut and inserted in another starting hole that the band saw has no chance to enter the field of fret work.

It may be said to have influenced American architecture, which seems largely to have been arranged so as to give every opportunity possible, from crest and barge board to porch and railing, for the display of scroll sawing.

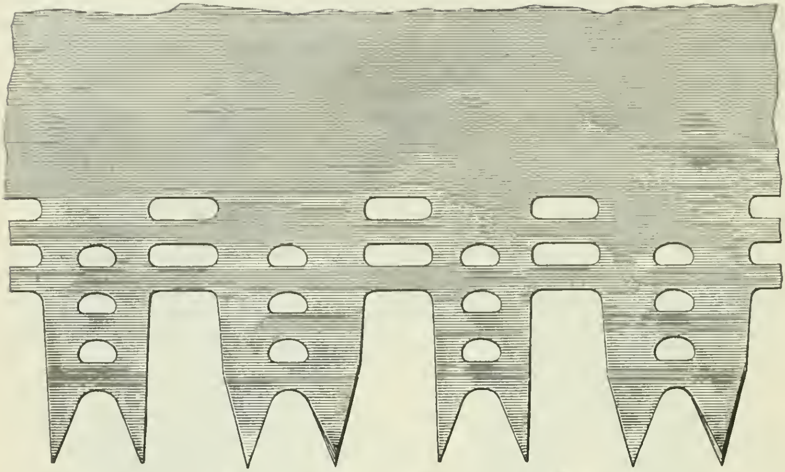


Fig. 36. Perforated Cross Cut.

Scroll-sawing blades are from 8 to 24 inches long and 13 to 16 gauge.

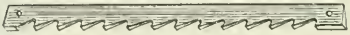


Fig. 37. Feather Edged Back.

We may only notice that most makers grind their jig saw blades at the back, to avoid all error of setting, while Andrews grinds to a feather edge (Fig. 37).

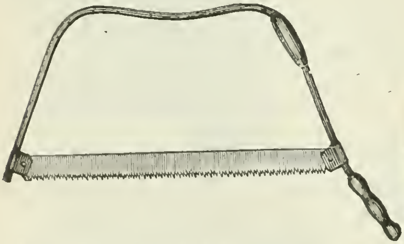


Fig. 38. Andrews' Steel Spring Buck Saw.

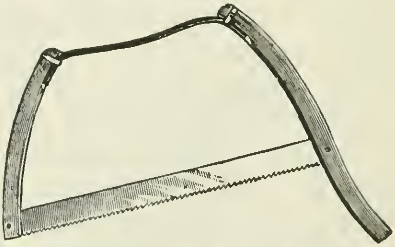


Fig. 39. Andrews' Bucksaw—Wood Frame, Steel Spring.

The larger sizes necessitate a blower to keep the kerf free from dust and enable the workmen to see the lines of the pattern.

The "Fleetwood No. 3" fret saw runs about 700 to 800 cutting strokes per minute. Faster speed is apt to heat the saw and burn the wood. Routers sometimes use a double-edged blade.

We hear of *round* saws for scroll work, but have not yet seen them.

The Buck Saw, or Wood Saw, is a familiar implement. It is made with the ordinary inclined V or hand saw tooth, and also with the double cutting M; the latter far superior.

American use has discarded the stick and twisted cord strainer.

In frames, recent improvements enable a much larger log to be taken in. Figs. 38 and 39 show Andrews' frames, where the straining is accomplished by a steel spring comprising a part or the whole frame.

Web saws $\frac{1}{8}$ inch and narrower have wide ends, in order to give strength at the holes.

(To be continued.)

Gold in Petroleum.—According to John Turnbridge, gold may be found in the ashes of crude petroleum and in the refuse of petroleum stills.—*Der Bergmann.* C.

Electric Discharge in Gases.—Warren de la Rue and H. W. Müller publish the following results: 1. For each gas there is a minimum of pressure which corresponds to the minimum of electric resistance. If the pressure is diminished below this minimum the resistance increases rapidly. 2. There does not seem to be any condensation or expansion of the gas in the neighborhood of the electrodes. 3. The discharge is accompanied by a sudden, momemtary expansion of the gas, which does not appear to be due to the mere heating. 4. The ratio between the pressure and the difference of potential necessary to produce the discharge between two plane surfaces, at a constant distance, can be represented by a hyperbola; the same is true for the difference of potential and the explosive distance when the pressure is constant. 5. Between points, under atmospheric pressure, the potential varies as the square root of the distance. With a constant pile of 11,000 elements (chloride of silver), the explosive distance varied inversely as the pressure, from 1.5 mm. to 15 mm. (·059 inch to ·5906 inch). 6. The electric arc and the stratified discharge in a vacuum appear to be modifications of the same phenomenon.—*Comptes Rendus.*

C.

ON THE CONSTRUCTION OF DOUBLE BEAT POPPET VALVES.

By William P. Tatham.

The ordinary construction of these valves is shown in Fig. 1, in which the sectional lines representing the seats of the valves make angles of about 45° with the axis. The dotted lines in all the figures show in an exaggerated manner the effects of expanding the valve by heat.

The trouble with them is in making and keeping both valve seats steam tight, and to this end it is not unusual to cast the valves and valve seats at the same running, so as to have metal of equal expansibility, and to grind the valves to their seats when hot, *i. e.*, under working conditions.

The object of this paper is to exhibit a principle of construction which would secure the desired result, provided that the touching surfaces of valves and seats be portions of true cones, and provided also that the expansion of the valve throughout itself be uniform, and that the expansion of the seats throughout be uniform also, however much these two expansions might differ one from the other.

Under these conditions, it is only necessary that the imaginary apexes of the two cones of which the valve seats are portions should be at the same point. This will secure a tight fit of both valve plates to their respective seats, with different expansion.

Let *ABC*, Fig. 2, represent a section of a solid cone of brass fitting closely a hollow cone of iron, or less expansible metal. When heated, the brass cone would expand and become a larger but *similar* cone, a portion of it still fitting the iron cone and the rest projecting above it, as shown by the dotted line *bc*.

Again, let *ADE* be a section of another solid cone of brass, having the same apex as the cone *ABC*, and fitting in a hollow cone of the same iron as in the first case. When expanded by heat, the brass cone would fill the hollow cone as before, and the expansion would be represented by the projection outside, indicated by the dotted line *d e*.

Now, what is true of these solid brass cones is true of any portion of them, and if we shape them into a valve, as shown by the shading, it will have the property required.

It follows, that if the cone of the top plate have its imaginary apex on a level with the bottom seat, that seat must be flat, as in Fig. 3.

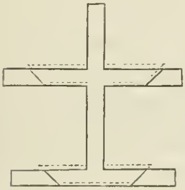


Fig. 1.

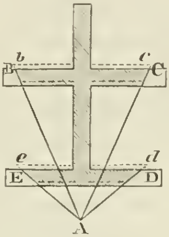


Fig. 2.

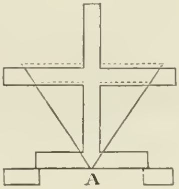


Fig. 3.

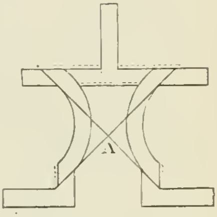


Fig. 4.

If the imaginary apex be above the level of the bottom seat, then to make a common apex to the two cones the valve must take the form as shown in Fig. 4, which is very near to Hornblower's original double beat valve.

The same principle applies to the Cornish valve. The common apex may be considered as the point of no movement, every other part expanding radially therefrom.

Even if the preliminary conditions which I have required cannot be secured, it would seem that a correct construction would diminish the chances of leaky valves, and perhaps do away with them altogether.

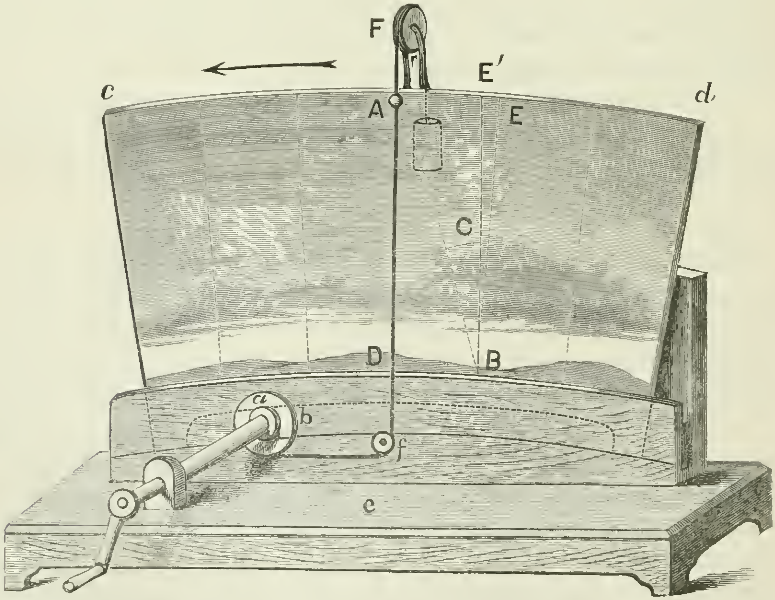
Alloys of Copper and Manganese.—An alloy, containing 70 per cent. of copper and 30 per cent. of manganese, is employed in Germany as an addition to brass or to bronze, in order to increase the density, the tenacity and the ductility of those metals. The manganese, in consequence of the ease with which it oxidizes, prevents the formation of the oxides of copper or tin which, in the ordinary process, alter the nature of the product. The employment of metallic manganese is also recommended for the same end. The addition of from one quarter to one per cent. of the manganese, or of from three-quarters to three per cent. of the alloy of manganese and copper, produces castings without blow holes. A larger proportion of manganese hardens the metal and gives to the bronze properties similar to those of steel.—*Bull. du Mus de l'Ind. de Belg.*

DESCRIPTION OF AN APPARATUS FOR ILLUSTRATING "THE ABERRATION OF LIGHT."

By Thomas William Tobin,

Professor of Chemistry and Physics, Central University, Richmond, Ky.

Amongst the many appliances of the modern physical laboratory for the illustration or explanation of natural phenomena, I do not know of any specially devoted to that somewhat complex yet beautiful principle, the "aberration of light." The illustration of "a projected stone passing through a railroad car while in motion" is one only of comparison, and does not present satisfactorily the actual phenomenon to the mind of a student. With this fact in view, I constructed a piece of simple mechanism, which is actually a model of the reality, and the experiment having proved successful, I herewith append a description of it for general use:



The construction will be easily understood by reference to the accompanying diagram; *c d* is a movable disc in connection with the pinion *a; b* is a grooved wheel on the same axle as the pinion, attached to which is a silk cord passing over the fixed pulleys *f* and *F*, thence to a counterweight at the back of the disc *c d; A* is a silvered glass bead on the silk cord; the whole is mounted on a stand *e*.

In the year 1725 Dr. Bradley, while making observations upon the fixed stars, with a view of finding parallax and distance, discovered the displacement of their images in the heavens. He explained in a satisfactory manner the cause in the aberration of light. By subsequent minute observations upon the character of the phenomena, this aberration was accounted for by the progressive motion of light, which he thus found to be 192,600 miles per second.

Römer, the Danish astronomer, had, some 50 years previously, also in an unexpected manner, determined the velocity of light, by observations of Jupiter's satellites, to be 192,000 miles per second.

Now, the apparatus already described is intended to explain how this velocity by Bradley was ascertained. Suppose the observer to be stationed at *B* and the earth stationary in space; the image of a star, a little to the left of the zenith, coming in the direction *E' B* would enter his telescope in that line. The velocity with which the image entered, great or small, would not affect the direction of the line of sight. Let now the image of a star at *A* be represented by the silvered bead, having a velocity *AD* per second of time; in other words, let the distance *AD* represent the velocity of light per second. While the image would appear in the line *AD* to an observer at *D*, if the earth were stationary, a very different result presents itself to the observer at *B*, when the earth has motion in the direction *BD*. Now, we will take *BD* to represent the velocity of the earth's motion in space during one second, and the mechanism of the apparatus will then show the progressive motion of the image *A* towards the observer at *B;* it will follow the dotted line *AB*. The arc at *C* represents the angle of displacement or aberration.

The problem of Dr. Bradley may be now easily stated: *DB*, the motion of the earth in space, was known; the arc *C* he ascertained by observation to be 20 seconds; the line *AD*, representing the velocity of light, he calculated by simple trigonometry to be 192,600 miles. It was one of the most interesting and important astronomical discoveries ever made, and confirmed Römer's previous discovery of the progressive motion of light.

ON THE ACID PRODUCTS OF THE COMBUSTION OF COAL.

An essay read by Mr. VINCOTTE, Engineer-in-Chief of the Association of Bruxelles,
Belgium, to the Meeting of the Engineers-in-Chief of the Association of
Proprietors of Steam Apparatus, held at Lille, the head-
quarters of the Association of the North of
France, on the 9th, 10th and
11th of July, 1876,

Translated by Chief Engineer ISHERWOOD, U. S. Navy.

The gases of combustion deposit on the heating surfaces of boilers different substances of great importance as regards the durability of the metal composing those surfaces and its power of transmitting heat. These substances are principally soot, tarry matter, sulphuric acid and ammoniacal salts.

The quantity of soot in the gases depends on the kind of coal consumed and on the intensity of the chimney draught, but whether great or small, a portion is always deposited on the heating surfaces.

The soot in immediate contact with the surfaces is cooled by them below the temperature of combustion, but when the deposit attains a certain thickness, the portion most distant from the surfaces burns whenever the hot gases of combustion passing over it contain sufficient free oxygen. The thickness of the soot deposit which escapes combustion depends on the temperature of these gases at any particular point considered, and should, therefore, after the boiler has been some time in use, be found to increase from the furnace to the chimney.

On all the heating surfaces where the gases of combustion have a sufficiently elevated temperature to burn the outer portion of the soot deposit, the unburnt inner portion is found covered with a white layer of ash from the burnt portion, and this ash has a thickness limited only by its cohesion; generally, it increses until the surfaces are swept.

On the heating surfaces where the temperature of the gases of combustion is too low to ignite the soot, the latter remains black and its thickness continually increases until it falls off by its own weight, which does not happen soon. The following are some examples:

1st. The case of a boiler with a feed-water heater. The gases of combustion pass first beneath the boiler and then return enveloping the heater.

The soot deposit has the appearance described below; I analyzed specimens from two places, one in the boiler at the end of the flue beneath it, the other in the heater not far from its chimney end.

On the boiler the soot formed three layers: one grey, passing insensibly into the second which was black; the third layer, under which the boiler iron was white, was formed of the white matter above described. On the heater there were but two layers; the outer one was greyish-black and the inner one was white at its contact with the metal.

Deposit from the Boiler.

	(1) Mixture of the two exterior layers.	(2) White substance in contact with the metal. Specimen taken beneath the preceding one.
Ferric sulphate and ferrous sulphate,	72·00	89·00
Ferric oxide and alumina, . .	18·00	0·00
Free sulphuric acid, . . .	0·00	2·00
Sulphate of lime, ...	0·00	5·00
Carbonaceous matters, . . .	5·00	3·00
Silica, ...	1·00	1·00
Water, ...	4·00	0·00
	100·00	100·00

Deposit from the Heater.

	(3) Exterior layer.	(4) White substance in contact with the metal.
Ferric sulphate and ferrous sulphate,	37·00	81·00
Ferric oxide and alumina, . .	3·00	3·00 (alumina)
Free sulphuric acid, . . .	3·00	2·00
Sulphate of lime, ...	6·00	0·00
Sulphate of ammonia, . .	2·00	3·00
Carbonaceous matters, . . .	22·00	0·00
Silica, ...	3·00	0·00
Water, ...	24·00	11·00
	100·00	100·00

The boiler and the heater had some very small leaks, passing probably only a few drops of water. Nevertheless, each leak was surrounded by a small cavity filled with iron rust and with calcareous salts deposited from the water. I analyzed the products of this corrosion and obtained the following:

	(5) Leaks near specimens 1 and 2.	(6) Leaks near specimens 3 and 4.	(7) Leak in the heater.	(8) Leak in the heater.
Ferric sulphate, . .	6·00	65·00	0·00	4·00
Sulphate of lime, .	28·00	4·00	8·00	13·00
Ferric oxide and alumina,	65·00	24·00	23·00	77·00
Silica, . . .	1·00	2·00	2·00	3·00
Carbonate of lime, .	0·00	0·00	67·00	0·00
Carbonaceous matters,	0·00	5·00	0·00	3·00
	100·00	100·00	100·00	100·00

If a piece of iron be plunged into a mixture of water and any one of the substances 2, 3 or 4, it will be violently attacked, with disengagement of hydrogen and formation of ferric sulphate. From this the inference is natural that a rapid corrosion of the boiler metal will be produced every time the soot becomes humid. The great variety observed in the products of corrosion depends on whether the leaks are of long standing or recent, and are probably influenced by different circumstances.

2d. The case of a boiler formed with two principal shells juxtaposed, and a feed-water heater.

On the two principal shells the soot formed the three layers above described. After the boiler had been some time out of use the appearance of the soot completely changed; it fell from the metal in the form of a shriveled skin, and the layers no longer continued distinct.

The exterior layer was analyzed at three different periods:

1st. Immediately after the boiler was put out of use.

2d. Some days afterwards.

3d. About a month afterwards.

The last two specimens, however, did not represent the pure exterior layer, for at the end of a month it could not be separated from the second one.

The specimen taken immediately after the boiler was out of use was white and very dry. It contained only traces of the salts of iron, and was composed principally of alumina and silica, with a little ammonia and a very notable quantity of sulphates of alumina and of lime.

The specimen taken after some time was pinkish-white and a little unctuous to the touch. It contained

Free sulphuric acid, ...	3·00
Ferric sulphate, ...	77·00
Sulphate of ammonia, ...	2·00
Sulphate of alumina, . . .	5·00
Sulphate of lime, ...	3·00
Ferric oxide, ...	4·00
Silica, ...	3·00
Water, ...	3·00
	100·00

The specimen taken after a month had different tints of grey mixed with yellowish-green. It was unctuous to the touch, and had the following composition:

Water, by desiccation at 212° Fahr., . .	36·1
Anhydrous sulphuric acid, calculated, .	36·0
Ferric oxide, ...	20·7
Ammonia, alumina, bituminous matters, and water of combination, . . .	7·2
	100·0

From the above it is probable that the exterior white layer contained neither free acid nor sulphate of iron during the time the boiler was in use, and that these substances were formed afterwards by imbibition when the two exterior layers became humid.

3d. The case of a horizontal boiler with two feed-water heaters. At the time of my examination it had been out of use a month, and the deposit on the heating surfaces of the boiler was in three layers.

On the exterior the substance was white, soft to the touch, and very light. Beneath was a blackish substance forming broad scales; finally, in contact with the metal, was a light layer of rust.

The black scaly matter melted by heat in its own water of crystallization, and had the following composition:

Sulphuric acid, ...	24
Ferric oxide and alumina, . . .	·37
Ammonia, ...	2
Silica, ...	3
Carbonaceous matters, ...	1
Water, ...	33
	100

The white matter contained

Sulphuric acid,	12
Alumina and ferric oxide,	54
Silica,	14
Organic matters,	2
Water,	18
	100

The corrosion is here seen in successive action.

The white substance immediately in contact with the metal has disappeared, and the rust, mixed with different salts, occupies its place.

The black layer contained ferrous and ferric sulphates; it has become hydrated and the salts have crystallized, giving the mass the appearance of black scales.

Along the lines of the rivets of the heaters were various leaks, which had strongly corroded the metal.

The white substance in contact with the metal has become transformed into a layer of rust, as always happens when boilers are out of use.

4th. The case of a boiler having interior furnaces, and in which the gases of combustion pass first through the flues behind the furnaces, then return through two flues by the sides of the boiler, and thence descending, pass in the original direction through a flue beneath the bottom of the boiler.

In 1873 the existence of large leaks in all the flues of this boiler was known. The whole of the metal was corroded to depths of from $\frac{1}{12}$ to $\frac{1}{8}$ of an inch. The defective rivets were made tight; the leaks ceased, and with them the corrosion.

The deposit on the heating surfaces had the ordinary appearance. In the side flues the white substance in contact with the metal was very abundant, and had the following composition:

Anhydrous ferrous sulphate,	28
Sulphate of alumina,	17
Silica,	8
Alumina,	6
Water,	40
Metallic iron,	1
	100

The metallic iron came, without doubt, from the action of the chisel employed to detach the specimen.

The substance contained a great deal of water, nevertheless the metal was not rusted, which seems due to the fact that there was ferrous sulphate instead of ferric sulphate, the former being crystalline and dry notwithstanding the water it contained.

5th. The case of a vertical boiler with flat flues, heated exteriorly.

The examination took place three days after the boiler had been put out of use. All the heating surfaces were covered with a substance unctuous to the touch, and of a grey mixed with yellow and green color. A specimen taken from the flues at mid-height had the following composition:

Ferric sulphate,	41
Ferric oxide,	18
Sulphate of alumina,	9
Alumina,	9
Silica,	7
Sulphate of lime,	6
Water,	10
	100

The seams of this boiler showed some small leaks, which had deeply pitted the metal.

It is needless to here dwell on the disastrous influence which the soot exercises on the transmission of heat as soon as its thickness becomes sensible, and, consequently, on the necessity of frequently sweeping all the heating surfaces.

When fat coal is consumed only several days are required to form a layer of soot so thick that sweeping will not appear superfluous, but with the coal ordinarily used in steam boilers a much longer time is required, and a monthly sweeping produces marked effects.

Besides soot, the gases of combustion always contain a certain quantity of tarry matters in the state of vapors, which condense on contact with the heating surfaces and form upon them a layer of pitch.

With fat coal all the heating surfaces are sometimes found covered with pitch, but in general only those nearest the furnace are thus coated. The furnace surfaces have oftenest no other deposit than a thin layer of black pitch, which is useful in showing whether they have been overheated. In fact, it can be taken as a rule, even with the lean semi-fat coal generally used, that the plates of the furnaces where no layer of pitch is found have been too much heated, either because of insufficient cleaning, or too much forcing of the fires.

There does not appear a satisfactory theory of the formation of the sulphuric acid. It may, indeed, be said that all the coals burned in boilers contain sulphur, whose combustion would naturally produce sulphurous acid, which encounters amid the gases of combustion free oxygen, aqueous vapor, and other substances necessary to its transformation into sulphuric acid; but what those substances are, or how they react is unknown. Be that as may be, it is found on all the heating surfaces not coated with pitch, and forms there in immediate contact with the iron beneath the soot a very thin layer of ferric sulphates, with which it remains mixed.

The quantity of acid thus found on the heating surfaces is so much the greater as their temperature is lower. It increases from the furnace to the chimney, and when the boilers are fitted with feed water heaters the acid is most abundant on them, where it is found not only in contact with the metal, but throughout the whole layer of soot there, which is impregnated with it.

Possibly the more or less sulphur in the coal may influence the quantity of acid which the heating surfaces condense. I have not yet had the opportunity of making a formal investigation, but at the first view the phenomenon presents itself rather as if, with all the ordinary coals, there always existed a great excess of acid, of which the heating surfaces condense as much as their temperature permits. The quantity of sulphur in the coal would then only have influence on the time required for the production of that amount of acid, and as in the circumstances necessary to be reproduced the acid and the iron remain in the presence of each other without combining, the percentage of sulphur in the coal would only have to be considered for the case in which the acid attacks the iron and constantly corrodes it.

To sum up, when a boiler is heated with semi-fat coal and examined after the fire is withdrawn, the heating surfaces are found covered with the following products of the combustion:

1st. Above the fire is a thin layer of very dry pitch mixed with soot, and ordinarily a little acid and astringent; if, however, portions of the surface have been overheated the pitch will have disappeared from them. Upon the pitch is some clinker, derived from the ash mechanically carried up, which, being intercepted by the rivet heads and other projections, is partially fused there.

2d. Farther on are found three very distinct layers. The first, in immediate contact with the iron, is thin and white; it is composed of from 80 to 90 per centum of ferrous and ferric sulphates, 2 to 3 per centum of free sulphuric acid, a small quantity of ammoniacal salts, sulphate of lime, etc. Under this layer the iron is white and clean; sometimes it is brilliant.

The next layer is black soot mixed with a little acid, and with salts of iron and ferric oxide, derived probably from anterior decompositions. This layer of black soot increases in thickness as we proceed towards the chimney.

Lastly, the outer layer is composed of a white or pinkish substance, very soft, very adhesive, and very dry, composed of alumina, silica, and sulphate of lime, and when of great thickness its external portion sometimes melts, and forms small, greenish, vitreous grains. Ordinarily the layer is compact, but sometimes when very fat coal is used, it is flaky.

3d. Still farther towards the chimney the outer layer diminishes in thickness, and disappears after having become greyish. There is then found only the white and acid substance in contact with the iron, and the black soot which sometimes becomes from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch thick when not removed by sweeping.

With fat coal the difference is that the layer of pitch extends farther at the expense of the surface covered by the acid.

As soon as the boiler is put out of use the different products just enumerated become rapidly modified, and an examination finds them under very varied forms.

The sulphuric acid quickly attracts the surrounding humidity, becomes diluted, and penetrates by imbibition into the soot which absorbs it.

The mixture of ferrous and ferric salts acts in an analogous way, depending, however, in a very notable manner on its composition, whether ferrous or ferric. When there is only a little ferrous sulphate it attracts enough humidity to furnish its water of crystallization, and crystallizes into a very dry substance, which is only transformed slowly and has not, under ordinary circumstances, further action on the metal. The ferric salts, on the contrary, when in certain quantity, are deliquescent or not, according to the hygrometric state of the flues. I have had specimens which in one corner of my laboratory were deliquescent and in another warmer corner were not.

The soot, when sufficiently moistened, diminishes greatly in volume. It often becomes loosened, twists like a peeling and hangs from the heating surfaces in tatters, of which a large portion falls at the first accession of heat.

The acid, once slightly diluted, attacks the iron. The ferric salts act in the same manner, and after a time, depending on the humidity of the flues, the white layer in contact with the iron grows yellowish, and then, little by little, changes into a thick layer of rust, impregnated with sulphate of iron. It is by the appearance of this layer, after the boiler has been some days out of use, that we ascertain whether the flues are humid. If it grows yellowish after two or three weeks, we can conclude that the thickness of the metal is rapidly undergoing a general diminution, and that this corrosion is due to humidity, whose cause should be discovered and removed.

As regards the preservation of boilers, all the preceding is summed up in some leading facts.

1st. Nearly all the heating surfaces of a boiler are covered with sulphuric acid, but this acid attacks them only in an insensible manner. Boilers forty years old are met with whose heating surfaces have always been covered with acid without diminishing their thickness $\frac{1}{25}$ of an inch.

2d. As soon as this acid in any way acquires humidity, it becomes very corrosive and rapidly pits the iron.

3d. An examination of the flues shows at a glance, simply by the appearance of the products, if humidity be present. If it be, the cause must at once be discovered and the effects ascertained.

The principal causes of corrosion by the acid products of the combustion of coal that I have observed are the following:

1st. *Leaks.*—Although any water that may be leaked into the strongly heated flues dries quickly, there always remains around the leak a small humid zone, where the acid in the gases of combustion preferably condenses, becomes diluted, and then acts upon the metal. In the cooler flues the effects of leaks are worse, inasmuch as the extent of surface wetted is greater.

As regards leaks, it is important to ascertain in each case whether they are due to local causes or to a general cause. If local, a repair stops them; if general, the fault may not be in the workmanship of the boiler itself—it may be in the arrangement of the flues, in the manner of feeding, or in the forced combustion, in which cases the leaks will continue to break out as often as they are stopped. Adding another boiler often stops the leaks of the others.

2d. The humidity present at the front of boilers, and which is carried into their flues by the draught when the boilers are out of use.

I have witnessed cases where a gutter passing in front of boilers received their water when run out. This gutter also received the discharge from several gauge-cocks, so that aqueous vapor was always rising from it. After some time all the boiler plates were notably rusted.

In other cases the boiler water was run out into the ashpit, during which operation the aqueous vapor entered the flues, diluted the acid products, and, at each time the boiler was allowed to cool, pitted its plates a little. A cause of humidity that only operates occasionally suffices to destroy a boiler at the end of several years.

3d. The natural or artificial humidity of the flues.

Above all, it is necessary that water should not enter the flues when the boiler is ran out or emptied, because they would then continue humid all the time the boiler remained out of use, and the corrosion would rapidly go on. It is also necessary to prevent any water that may fall on the masonry or setting of the boiler from entering the flues.

4th. The too low temperature of some of the flues.

If the hygrometric state of the gases of combustion be such that the aqueous vapor they contain can condense on the heating surfaces of the boiler or of its feed-water heater, these surfaces will remain constantly humid and rust very rapidly.

5th. When the flues of a boiler out of use are in communication with the flues of another boiler in use, the acid vapors in the gases of combustion from the latter will condense on the heating surfaces of the former.

Heating Boilers by Electricity.—Charles Davis, of Paris, proposes to fasten a number of spirally wound platinum wires in an ordinary steam boiler, and to send through them an electrical current of sufficient strength to boil the water. He does not say how he will produce the requisite amount of electricity, nor at what cost per horse power he expects to furnish the steam.—*Dingler's Jour.* C.

MICA.

By THEO. D. RAND.

Of commonly occurring minerals, few are more remarkable than those of the mica family. Originally, the word mica was applied to a variety of minerals closely resembling each other, then supposed to be identical, but which the advance of science has shown to be distinct species, so that now the term is applied to a large class of minerals, the distinguishing characteristic of which is their readily splitting into thin laminæ.

Common mica, or Muscovite, is very abundant in most of the older rocks, it being a constituent of gneiss, granite and micaschist.

It splits into thin laminæ, or leaves, very readily. This is due to cleavage, or the property, possessed by most crystalline substances, of breaking most readily in certain planes, which bear a relation to the axes of the crystals. For instance, take a crystal, or fragment of a crystal, of galena, or of rock salt; break it into small pieces, and these, if you will, again and again, even until a microscope is needed to see the form of the grains; nearly all the fragments, large and small, will be found to be rectangular in shape, or with sides parallel to the faces of a cube, the crystals dividing readily into that form, and into no other. If fluor spar be treated in like manner, the surfaces of its fragments will be found to be parallel to the faces of an octahedron. A crystal of common feldspar, or orthoclase, similarly treated, will give rectangular cleavages on four sides, but the remaining sides will, in almost all specimens, be found to be wholly destitute of cleavage, and to break with difficulty, and irregularly. The readiness with which the specimens will cleave will be found to differ. The galena breaks with great ease into perfectly rectangular blocks, with smooth and shining surfaces, the salt likewise, but less easily; the fluor spar breaks still less readily, and more care is required to obtain a smooth surface; the feldspar breaks with great ease in one direction, and with much less ease in the other at right angles. These examples will help us to understand the cleavage of mica. It (generally) cleaves in one direction only, but in that direction its cleavage is almost perfect, and very easy indeed. To this property, and to the fact that it is unaltered by a moderate heat, is due its large use for doors for stoves, etc., for closing the eye holes of blast furnaces, and other similar purposes. Occasionally a second cleavage exists, and when this is the case the result is long fibres almost hair-like in appearance.

Chemically, mica is a silicate of alumina and potash with a small amount of iron, magnesia and soda, and usually from one to five per cent. of water.

Another remarkable property of mica is its great elasticity and toughness. It is equaled in these respects by very few materials, and in the combination of the two it is probably excelled by nothing natural or artificial.

Granite is composed of crystals, or crystalline masses, of mica, quartz and feldspar; sometimes the crystals or masses are very small, as in common granite; sometimes very large, and when so, the mica becomes valuable; the granite is a "mica mine."

Formerly, nearly all the mica used in the United States came from Russia, whence crystals over a yard in diameter are said to have been procured; but now several mines are, and have been wrought in the United States, especially at Grafton, N. H., and in Western North Carolina.

A large amount of mica was obtained from an opening in the southern part of Chester county, Pa., not far from the celebrated Dixon's quarry. It occurred in a granite vein, in which, as is very commonly the case, the feldspar had become wholly decomposed into clay, leaving the quartz and mica unaltered. The vein was followed nearly vertically some forty or fifty feet. Crystals of mica over two feet across and weighing over a hundred pounds were obtained, much of it of excellent quality, but some of it rendered nearly opaque by dendrites of magnetic iron between the films of the mica, rendering it useless for stove purposes, but forming cabinet specimens of great beauty. The quarry, which gave promise of considerable yield (properly wrought), was neglected, until the sides of the excavation caving in, it was abandoned.

As we have stated, the varieties of mica, now distinguished by mineralogists, are numerous—the most common after muscovite are:

Biotite, generally of a dark color—the black mica so abundant in many granitic and gneissic rocks.

Lepidomelane; black, and not distinctly separated from biotite.

Phlogophite; generally brown or red—the mica occurring in limestones.

Lepidolite; a red or pink mica containing the rare earth lithia.

Mica, like most other minerals, is found to change by long exposure to atmospheric influences, but the muscovite seems least susceptible to such decomposition, and to be more stable than the feldspar which usually accompanies it,—there results a micaceous soil, so common in some parts of our country, as in Philadelphia. Often such mica becomes red and yellow in color, probably from oxide of iron, and the instances are numerous in which it has been mistaken for gold. It is believed that the class of minerals known as the vermiculites have resulted from an alteration of mica, chiefly by the absorption of water. These are characterized by a very great and powerful expansion when heated. This expansion increases the bulk enormously, and the force is sufficient to break a test tube if the mineral be heated in it.

Mica ground in a mill increases vastly in bulk and forms a loose light mass of scales not unlike bran. It is largely used in this form in the so-called mica powder as an absorbent of nitroglycerine, its peculiar elasticity rendering accidental explosion by percussion almost impossible, while it does not interfere with the energy of the nitroglycerine when exploded by a fulminate or other similar device.

To the microscopist a world of interest may be found in the micas. They frequently contain, between the layers, microscopic crystals of minerals, some of them, especially with polarized light, forming specimens of wonderful beauty. Of most minerals, sections for microscopic examination must be made by the laborious process of grinding and polishing, but in mica we may almost say the sections are made by nature, and the time required to make one section of most minerals will make at least a hundred of mica, and the thickness or thinness is a matter of perfect control.

Perhaps the richest mica in these crystals, at least in variety, is that from the locality mentioned in Chester county, Pa. Most abundant is magnetite, or magnetic iron, usually in beautiful arborescent forms, black in color, but sometimes, probably owing to a change into limonite or gothite, various shades of yellow. Quartz crystals, generally flattened, sometimes perfect, are not uncommon, and form, with polarized light, specimens more brilliant than any other mineral. Besides these, various other forms occur, the identification of which with known species has not yet been accomplished.—*Science Advocate.*

A NEW LECTURE EXPERIMENT—THE CUPELLING OF GOLD AND SILVER.

Mr. Holman, the Actuary of the Institute, has constructed a lantern for the oxyhydrogen light which combines a great many advantageous qualities. It may, at a moment's notice, be changed into a vertical lantern for showing precipitations, the action of a magnet on iron filings, etc., on the screen. It may be converted into a projecting microscope in a twinkling, and with equal facility it becomes a megascope for projecting the image of solid objects. A course of lectures by Mr. A. E. Outerbridge, Jr., of the U. S. Mint, was recently delivered before the members of the Institute on "Coins and Coinage." By the aid of Mr. Holman's apparatus the enlarged images of rare and valuable ancient and modern coins were projected upon the screen with great sharpness and brilliancy, having the lustre and effect of relief of the coins themselves, and the lecturer was enabled to show the cupellation of gold and silver, as performed in the assaying of the precious metals at the Mint, in a very beautiful manner to the entire audience, thus opening up a new field of usefulness for the projecting lantern in illustrating lectures on metallurgy.

A little "cupel" or crucible, made of calcined bone ash, was held in the focus of the light from the condensing lenses of the lantern, by means of a ring of thick copper wire. The image of the cupel appeared upon the screen greatly enlarged. The cupel was then heated to a white incandescence by means of an oxyhydrogen blowpipe. A weighed sample of gold alloy containing base metal was enclosed in an envelope of sheet lead pressed into the form of a bullet; this was dropped into the cupel and was immediately melted. As the lead became oxidized it was gradually absorbed in the cupel, forming a dark ring in the bottom. A little sheet of light was noticed moving over the surface of the molten metal as the non-oxidizable precious metal became exposed to view; then, at the moment that the lead became completely absorbed, carrying with it all the base metal originally contained in the alloy, the purified precious metal became visible as a brilliant globule, reflecting the light falling upon its surface like a mirror.

ON THE HEATING POWER OF COAL GAS OF DIFFERENT QUALITIES.

By Dr. W. Wallace.

Read at the Meeting of the Philosophical Society of Glasgow, December 3, 1879.

The extensive employment of coal gas for heating purposes, and especially for cooking, gives an interest to the question whether the heating power varies like the illuminating power, and if so, to what extent in the gas used in different towns? As regards illuminating power, we know that it varies exceedingly. In Aberdeen and Edinburgh it is 30 candles for 5 cubic feet per hour; in Glasgow, Paisley and Greenock, about 26 or 27 candles; in Liverpool, Manchester and Carlisle, about 20; in London and Dublin, 16; in Birmingham and many other English towns, 14; and in some as low as 12 candles. But as regards heating power we have no definite information, although there is a general belief that a rich gas has a greater calorific effect than one of poorer photogenic quality.

My attention having been directed to the subject by a correspondent, I caused a small apparatus to be made, in order, when opportunity offered, to test the matter practically. It is of very simple construction, consisting of a cylindrical tin-plate vessel, 8 inches in diameter and 6 inches high, with a cylindrical opening in the centre, 1½ inches in diameter, through which the whole of the products of combustion pass. It contains exactly one gallon of water. Below is a brass tube bent into a circle 5 inches in diameter, and pierced with 34 small holes, from which the gas burns with flames about ¾ of an inch high. This tube is placed 1 inch from the bottom of the vessel, and is surrounded by an outer case having a sufficient number of small holes for the admission of air. On the top of the vessel there are two openings, in one of which a delicate thermometer is placed, while the other is provided with an open glass tube.

The opportunity of using the apparatus occurred recently, when I had occasion to test, on the same day, three samples of coal, which gave gas of 33, 26 and 15 candle-power respectively. Each experiment occupied, as nearly as possible, thirty minutes, and consisted in raising one gallon of water from 60° to 160°F., and measuring the quantity of gas consumed in the operation. The system is by no means a perfect one, but the results are strictly comparative. These are arranged in the following table:

Illuminating Power of Gas in Standard Candles.	Durability of 1 C. Foot by flame 5 inches high.		Specific Gravity Air=1000.	Comparative Value for Lighting.	Gas consumed in Heating Experiment.	Heat Units Fahr. for 1 C. Foot.	Comparative Value for Heating.
	Mins.	Secs.			Cub. Ft.		
33·07	64	45	574	4s 10d	1·916	522	4s 5d
26·24	54	40	525	3s 10d	2·200	455	3s 10d
14·75	39	35	442	2s 2d	2·888	347	2s 11½d

The heat units represent the number of pounds of water heated 1°F. by the combustion of one cubic foot of gas. I have taken Glasgow gas of 26 candles at 3s. 10d. per 1000 cubic feet as the standard of value, and it will be seen at a glance that, while the heating value rises and falls with the lighting value, the amount of difference is by no means so great in the former as in the latter.

Having made these simple but instructive experiments, I naturally wished to compare the results with the theoretical heating values obtained by calculation from the composition of the gases. Unfortunately, I had no apparatus at the gas-works where the experiments were made for analyzing the gases, and the best I have been able to do is to make the calculations from two analyses by the late Dr. Letheby, one of 12 candle gas, and the other of London Cannel gas, the illuminating power of which is not stated, but which may be assumed to be somewhere between 22 and 23 candles. The analyses are given only, as is usual with gaseous mixtures, by volume, but I have, for convenience, calculated the composition by weight.

	Common Gas. 12 Candles.		Cannel Gas. 22 Candles.	
	Vol.	Wt.	Vol.	Wt.
Olefiant gas, etc., C_2H_4,	3·8	9·5	13·0	24·9
Marsh gas, CH_4,	39·5	56·5	50·0	54·8
Hydrogen,	46·0	8·2	27·7	3·8
Carbonic oxide,	7·5	18·7	6·8	13·0
Carbonic anhydride,	0·6	2·4	0·1	0·3
Nitrogen,	0·6	1·5	0·4	0·8
Aqueous vapor,	2·0	3·2	2·0	2·4
	100·0	100·0	100·0	100·0

Specific gravity (calculated),	387	506
Weight of a cubic foot in pounds,	0·0296	0·0387
Calorific power, C.,	11,790	11,754
" " F., pounds of water heated 1° by the combustion of 1 pound of gas,	21,222	21,157
Heat units for 1 cubic foot, C.,	345	455
" " " " " F.,	621	819
Pounds of boiling water evaporated by 1000 cubic feet of gas,	639	842

We see from this tabular statement that, while the heating power of the two gases is almost identical, weight for weight, the practical result when we take the same measure of gas is very different, the Cannel being much heavier than the common gas. I calculate that in my practical comparative test I have realised about 55 per cent. of the theoretical heating power, which is pretty nearly the proportion of effective heat obtained by the combustion of coal in a fairly well-constructed steam boiler.

The question naturally suggests itself, What is the comparative cost of heating by gas and coal? The calculation is a simple one. The theoretical heating power of ordinary soft coal may be taken at 13, that is, the number of pounds of boiling water evaporated by 1 lb., equal to 29,120 lbs. for a ton of coal, value, say, 11s. 6d., being the price of 3000 cubic feet of Cannel gas, the heating power of which is, say 2500. The gas, therefore, costs 11½ times as much as the equivalent quantity of coal, or, in round numbers, a penny-worth of coal gives as much heat as a shilling's-worth of gas. When, however, we consider the handiness, the cleanliness and the convenience of gas, it is not surprising that it is extensively employed as a source of heat, as an illustration of which I may state that in my own laboratory from 250,000 to 300,000 cubic feet are consumed annually, almost the whole of which is burned for the production of heat.

English Industrial Laborers.—The iron workers of England include 140,000 laborers in furnaces and forges, 169,000 in the manufacture of machinery, 5500 in steel works, 48,000 in shipbuilding, and about 200,000 in various branches of iron and steel manufacture, making about 570,000 in all. The mining population is about 530,000 and the laborers in cotton mills about 600,000.—*Chron. Indust.*

ARE THE CHEMICAL ELEMENTS SIMPLE BODIES?

The researches which have been made in the various branches of physical science during the last few years have many of them been of unusual importance. Some—the telephone and microphone, for instance—have already resulted in the invention of instruments of great practical utility, while others have opened up new fields for research, and bid fair to effect a complete reversal of the generally-accepted notions concerning Matter. As Prof. W. B. Rogers remarked, in his Presidential Address at the 1879 meeting of the New York Academy of Sciences, "In all branches of discovery we seem to be catching the clews of far-reaching thought that stretch out where as yet no man's foot has trodden The recent developments in chemistry, through the agency of the spectroscope, and the effects of heat in dissociation, have suggested, if they have not proved, that a number of the substances hitherto regarded as elements are hereafter to be regarded as compound. The investigation of the laws of chemical action following out the suggestions made at the beginning of the century by the great chemist Berthollet, in regard to the influence of man on chemical reaction, seems to promise most important discoveries in chemical statics and the possibility of applying mathematical reasoning and formulæ to chemical activities. The marvelous series of experiments presented recently by Crookes, in which have been exhibited the wholly unexpected phenomena which he has described under the designation of what was first referred to by Faraday as a fourth form of matter, which this illustrious experimentalist called radiant matter, seemed to open up a field of research and speculation until now wholly undreamed of. In truth, the active scientific workers have now been brought by their refined and novel researches to touch the near extremities of innumerable lines of thought and investigation, stretching out into unknown regions, whose exploration is to occupy the activity and reward the labors of a coming generation."

In discussing the question whether or not the study of the spectrum has thrown, or is likely to throw, any light on the ultimate constitution of matter, Dr. Balfour Stewart* recently referred to the fact that

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* Nature. "On some Points in the History of Spectrum Analysis: an Address to the Natural Philosophy Classes at Owens College, Manchester, November, 1879."

Prout first pointed out that the atomic weights of the so-called elements are very nearly all multiples of the half of that of hydrogen, so that the various elements may possibly be looked upon as formed by a grouping together of certain atoms of half the mass of the hydrogen atom. A most remarkable series of experiments was conducted by M. Stas to test this doctrine. He came to the conclusion that the atomic weights of the various elements were not precisely multiples of the half of that of hydrogen, there being greater differences than could possibly be accounted for by errors of experiment. But Dr. Stewart, calling attention to the great difficulty of obtaining substances absolutely free from all impurity, does not admit that Stas' researches settled the point in the negative, and points to the spectrum as a likely means of throwing some light on the question. Now Mr. Lockyer's researches tend to show that at sufficiently high temperatures the so-called chemical elements, or at all events some of them, are compound bodies. These researches were not undertaken with a view sf decomposing the elements. Mr. Lockyer was preparing a map of the solar spectrum on a large scale, and the work included a comparison of the Fraünhofer lines with those visible in the spectrum of the vapor of each of the metallic elements in the electric arc. (The complete spectrum of the sun, on the scale of the working map, will be half a furlong long; in mapping the metallic lines and purifying the spectra more than 100,000 observations were made, and about 2000 photographs taken.) The final discussion of the complete photographs of the spectra of the metallic elements compared with the spectrum of the sun led to the results which are exciting so much interest at the present time.

There are certain lines in the spectra of each element which appear long and thick; and it has been found that while such a line, for instance, is exceedingly prominent in some one element, other elements appear to possess it, only not nearly so prominently. Mr. Lockyer argued from this, that on the assumption that the elements are truly elementary, the line in the other elements was caused by traces of impurity. He has, however, found that there are coincidences in the lines of metallic spectra of two perfectly distinct kinds. There are coincidences of lines which are not the prominent lines of any one spectrum, and they give no signs of that variability of brightness that might be expected to characterize lines due to impurities; these lines he has called basic lines. In Mr. Lockyer's own words, "The temperature of the sun and the electric arc is high enough to dissociate some of the so-called chemical elements, and give us a glimpse of the spectra of their bases, just as in the case of the various salts of calcium there is a temperature which just allows us to get a glimpse of a line indicating the metal calcium common to them all."

To determine whether these basic lines varied in their behavior from other lines of spectra taken at random, Mr. Lockyer had recourse to the spectrum of sun-spots. The sun is surrounded by an enormous atmosphere which is supposed to contain the vapors of such metals as iron and magnesium; but whether this be so or not, Mr. Lockyer argued that the atmosphere would certainly be hotter at bottom—near the photosphere—than higher up, and that the spectrum of the atmosphere close to the photosphere would differ from that of any higher region, and therefore from the general spectrum of the sun. In observing the spectrum of a sun spot, or a prominence, the spectrum of an isolated mass of vapors in the hottest region open to inquiry can be determined, and Mr. Lockyer found that this spectrum differed greatly from the general spectrum of the sun. The whole character of the spectrum of iron, for instance, is changed when we pass from the iron lines seen among the Fraünhofer lines to those seen among the spot and storm lines. As therefore the spectra of spots and prominences are from the hottest region of the sun, Mr. Lockyer employed them for testing these basic lines. The result has led him to conclude that their appearance in two or more spectra is dependent solely upon high temperature. The basic lines are more prominent in the spectra of spots than in the spectrum of the sun; they are, moreover, more prominent at epochs of sun-spot maximum than during times of minimum. The statement, then, that the spectrum of each element consists only of lines special to that element, is found to be insufficient when the highest temperatures and the greatest dispersions are employed.

A clearer conception of what is meant by the so-called elements being split up at a very high temperature will be gathered from the following illustration, given by Dr. Balfour Stewart: "If we apply a very powerful source of electricity, we obtain certain peculiar lines from the vapor of calcium. Now if we could catch hold of and segregate—put into a box, as it were—all these minute entities that give us this suspicious line at a high temperature, and, further, if we could keep their high temperature up, I think it is probable that we might obtain something which is not calcium, or, at any rate, something simpler than the molecule of calcium as this appears at lower temperatures. But we are not yet able, and perhaps we may never be able, at an ordinary temperature, to present the chemist with some other substance derived from calcium, which is not calcium."

Much, of course, remains to be done before Mr. Lockyer's views will be universally accepted. The indecomposable character of the bodies which we have hitherto considered elementary has for a long time been considered doubtful. Mr. Lockyer, however, is the first to come boldly forward with experimental proof. What the final result of the discovery will be we cannot foretell. A physical problem, as Dr. Stewart says, begins like a rivulet. At its first introduction it is small and seemingly unimportant; constantly, however, as it winds along it receives accessions from various quarters, until at length it becomes a mighty river that is finally merged in the unfathomable ocean. This course is followed by all such problems. Each begins small, grows broader, and will finally bear us on to the unknown if we trust ourselves to its guidance.—*Journal of Science.*

Carbonic Acid in its Relations to the Winds.—Marié Davy states that the quantity of carbonic acid, at Montsouris, in one hundred thousand volumes air of varies between 22 and 36. He was at first inclined to attribute these variations to the neighboring influence of Paris, which is an abundant source of carbonic acid; while the woods and cultivated fields, at least during the season of vegetation, are an equally active cause of its disappearance. But he found that the northern winds, which come from Paris, contain less carbonic acid, on the average, than the southern winds, which blow directly from the country. He therefore suggests, as an explanation of the phenomenon, that the carbonic acid is found in greater proportion below than above the clouds. The south or southwest winds plough the surface of the ground, but the north or northwest winds plunge from the upper regions of the atmosphere towards the ground. Since 1864 he has thought it important to draw a careful distinction between the equatorial current and the rotary movements which accompany it. The changes of the wind, of the barometer, of the thermometer, and of the hygrometer, are due to the latter, while the proportion of carbonic acid depends upon the former.—*Comptes Rendus.* C.

REMARKS ON THE NEW METALS FROM GADOLINITE AND SAMARSKITE.

By M. M. Delafontaine.

Since M. Marignac and I published our memoirs on Terbia, in March, 1878, the real or supposed discovery of ten other rare earths has been announced by different chemists—namely, mosandria, philippia, ytterbia, decipia, scandia, holmia, thulia, samaria, and two others not yet named. As may be imagined, such a multiplication of bodies difficult to isolate and characterize has provoked skepticism, and it has been suggested that some of them may be duplicates. If the Academy will permit me, I will communicate my views on this subject, as the result of my own researches.*

In my researches on gadolinite and samarskite, I have always attached great importance to the atomic weights. When the equivalent of a base is found to be higher than that of the other members of the same group (decipia and ytterbia, for instance), I have not had the least doubt of the specific existence of this base. But, if this equivalent, on the contrary, should be intermediate between two others (philippia as compared with yttria and terbia), I naturally have multiplied experiments to make certain that I am not working with a mixture of known bodies. In this case the physical characteristics have sometimes been of great help. For these reasons, therefore, ytterbia, decipia and philippia appear to me definitely acquired for science.

Scandium is unknown to me; I can say nothing about it.

Nothing has taken place to make me change my opinion upon mosandrium since I proposed to erase it from the list of elements.

Samarium.—M. Lecoq published in February and August, 1879, two notes, one on a new earth obtained from samarskite and the other on samarium. The properties which he attributes to his unnamed earth do not appear to me to differ essentially from those of decipia, or rather to a mixture of decipia and terbia: samarium is only characterized by absorption rays, which appear to embrace a portion of those of decipium. I do not know any facts which would lead me to imagine that decipium is not homogeneous; its absorption rays increase and diminish together in all the treatments to which I have submitted it. The discovery of samarium therefore demands verification by further experiments.

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* Not having been for some time in a position to see the *Comptes Rendus*, I only know some of the notes on these new metals from what has appeared in the *Chemical News* of London. If, therefore, there is some misunderstanding on my part, it must be attributed to a want of sufficient information.

MM. Marignac and Soret have shown that Bunsen's erbia is a mixture of several bodies. With the assistance of M. Thalén, M. Clève has repeated their experiments with the same results. But the *savant* of Upsala has gone further than those of Geneva; he does not hesitate to give names to the supposed new metals which he believes to be the cause of certain spectroscopic differences. According to him, the ultra-red ray discovered by M. Soret characterizes thulium; the red and green rays ($\lambda = 640$ and 536) belong to holmium,* whose oxide is yellow and the nitrate less easily decomposed by heat than that of erbium; beyond this he has neither obtained the first nor the second in a state of even approximate purity.

Samarskite contains very little of the old erbia of Bunsen: the absorption spectrum of this latter is very feeble with the solutions obtained from it, and in particular the green and blue bands ($\lambda = 523$ and 488) of erbia (in a restricted sense) are feeble; on the contrary, the indigo band ($\lambda = 452$) shows much better. After having separated didymia, decipia, and almost all of the terbia, I submitted the formiate of the earth to fractional crystallization; the first products gave from 49 to 47 per cent. of base. They were reunited and recrystallized several times. In this way was separated a salt rich in terbia and mother liquors richer in yttria: these were rejected. The rest, calcined and combined with nitric acid, showed the indigo band very strong, and the others more feeble. This nitrate, dissolved or in crystals, was perfectly colorless; its base, of a beautiful clear yellow, had the equivalent 98 ($\gamma o = 74$, $\pi o =$ about 115). This was submitted to a series of partial decompositions by heat, which divided it into six products (A to F). The earth from the first, slightly clearer, had the equivalent 102; the crystals of its formiate were slightly rose-colored; its absorption spectrum showed the absorption rays of erbia (in a restricted sense), but deeper. The four products following (B to E) contained a more colored base; its nitrate, which was colorless, gave a spectrum consisting only of the red (640) and the green (536) rays, narrow, but much stronger than before, and of the large indigo band (448 to 455). The green ray of true erbia was reduced to a narrow trace; the blue had disappeared. These earths, B to E, could not be split up into yttria and terbia by any known means. Finally, the product F gave a feeble spectrum; its coloration and its atomic weight were less than those of the original mixture.

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* M. Soret likewise adds the indigo band, $\lambda = 452$.

I have called philippia the yellow oxide, distinct from terbia, which forms the bulk of the earths of which I have just spoken. It properties are those of the earth X of M. Soret and of M. Clève's holmia; this last-named, being a duplicate, should not be retained.

In strictness it may be supposed that philippia is a mixture of two oxides, one of which gives the indigo band (448 to 455), and the other the rays 640 and 536; but I know of no fact in favor of such a conclusion.

The so-called euxenite from North Carolina contains still less of the earths giving absorption spectra than samarskite—a trace only. Besides a notable proportion of terbia I have obtained from it a straw-yellow earth, with an equivalent ranging about 90, without absorption spectrum, and which does not appear to be a mixture of terbia and yttria. I am not yet sure whether samarskite contains it, and in particular whether my philippia may be soiled by it: this is a point which I hope to clear up very soon. I am also examining another base from samarskite which appears to have a great resemblance to ytterbia.—*Comptes Rendus.*

Magneto-mechanical Sorting Machine.—Breuer and Schumacher have invented a machine for separating the turnings and borings of brass and copper from those of iron and steel. The mixed metals fall upon a magnetized cylinder or drum, to which the iron and steel adhere while the copper and brass fall into a special reservoir below. There are two hollow cylinders, rotating in the same direction, so that the iron which escapes from the first cylinder is retained by the second. The surface of the cylinders is formed of flat bands or strips of soft iron alternating with strips of copper; each of the iron bands is in contact with a row of horse-shoe magnets. The adherent metal is removed by revolving brushes.—*L'Ing. Univ.* C.

Poisonous Toys.—The Parisian police have recently seized a number of caoutchouc toys, on account of the employment of poisonous colors in their manufacture.—*Chron. Ind.* C.

Coral Cutting.—The coral fishèrs of Italy reside mostly at Naples and at Torre del Greco. A school has been lately organized at the latter place, in an old monastery, for the purpose of giving special instruction in coral cutting and bringing that art to a still greater degree of perfection.—*Chron. Ind.* C.

Variations in Spectra.—Wüllner discusses the various theories of Angström, Plücker, Hittorf, Lockyer and Zöllner, in regard to the dependence of spectra upon impurities, temperature, pressure, etc. From a long series of experiments with nitrogen, he concludes that the changes from band to line spectra depend principally upon the diminishing number of the luminous molecules.—*Wied. Ann.* C.

Analogy between Fluidity and Galvanic Conductivity.—O. Grotrian finds an interesting relation between the reciprocal of the constant of friction in fluids and the galvanic conductivity of a number of salt and acid solutions. Let t designate the temperature of the fluid, f the temperature coefficient of fluidity and k the conductivity. Then the value of the coefficient $\frac{df}{dt}\frac{1}{f}$, in a change of concentration, always alters in the same direction as the corresponding coefficient of conductivity $\frac{dk}{dt}\frac{1}{k}$.—*Wied. Ann.*

New Luminous Tubes.—Trève introduces a Fizeau condenser into a great Geissler tube. The two poles of a current from a Ruhmkorff coil terminate in this condenser, by means of the ordinary electrodes, which are soldered into the glass and are attached to the 11th and 12th sheets of tinfoil. When the induced current passes into the condenser, if the tube still contains air at ordinary pressure, the usual rumbling is heard. If a vacuum is gradually made in the tube, the rumbling diminishes, and when the pressure falls to ·003 or ·004 m. (·118 to ·157 in.) no sound is heard; but a brilliant white light appears, shimmering like pearls from the leaves of the condenser, and entirely different from the phosphorescent, pale and flickering light of the Geissler tube.—*Comptes Rendus.* C.

Railway Sleepers.—The Belgian government has decided on the abandonment of wooden railway sleepers and the use of those of iron. Its example will doubtless find imitators, if indeed the example be not improved upon, and steel be used eventually instead of iron. It is not the longitudinal sleeper that has been adopted, but a German system of cross sleepers.—*L'Ingen. Universel.* C.

The Buda-Pesth Artesian Well.—The depth is 970·48 metres (3183·9 ft.); daily supply 7600 hectolitres (200,781·4 gal.); temperature 74° (165·2 F.); mean increase of earth-temperature 1° for 12·61 m. (1°F. for 22·98 ft.). The water is strongly impregnated with carbonic acid, together with some nitrogen and sulphuretted hydrogen; it contains 1·131 grs. of salts per litre (66 grains per gallon), principally sulphates and carbonates of potash, soda, lime, magnesia, with some chlorides. It resembles the Kaiserbad water, at Ofen.—*Jahresb. der K. K. geol. Reichsanst.* C.

Capillary Electrometer.—E. Debrun has presented to the French Academy a modification of Lipmann's electrometer. He avoids the use of a microscope, by observing displacements of the mercury in a cylindrical tube, with a diameter of a quarter of a millimetre (·01 inch), and fifteen centimetres (4·9 in.) long, divided into millimetres; this tube makes an angle of 10° with the horizon. The change of level is about seventy-five millimetres (2·75 in.) for a variation of a volt, which gives, with a vernier, a sensibility of $\frac{1}{750}$ of a volt. The tube is divided, experimentally, into parts of equal electro-motive force.—*Comptes Rendus.*

Deprez's Magneto-Electric Machine.—Deprez uses a horseshoe magnet, placing between the two branches a Siemen's coil, which is revolved around an axis parallel to the branches of the magnet and provided with proper commutators. The length of the helix is nearly equal to that of the rectilinear branches of the magnet, so as to use nearly all the inductive power of the branches*. With a battery of five Bunsen elements and a magnet weighing 1·7 kilogrammes (4·54 pounds), he obtained as satisfactory results as with a Gramme machine, which had a permanent magnet weighing at least 20 kilogrammes (80·4 pounds).—*Bull. de la Soc. Franc. de Phys.* C.

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*See JOURNAL OF THE FRANKLIN INSTITUTE, August, 1879.

The Pyrophone.—M. Kastner has given the name of pyrophone to an invention based upon the sounds which are produced by the hydrogen flame in tubes of glass. The instrument is played with a key-board like a piano, and the notes are remarkably sweet and sonorous.—*Badeblatt.* C.

Prof. Crookes in Paris.—On the invitation of M. Wurtz, Prof. Crookes took his apparatus to Paris and repeated his experiments upon radiant matter before the medical faculty, and also at the Paris observatory in a soirée given by Admiral Mouchez. The experiments were remarkably successful and were received with great applause.—*Les Mondes.* C.

Wide Diffusion of Copper.—Dieulafait has published a memoir upon the existence of copper, in a state of complete diffusion, in all the rocks of primordial formation and in all the sedimentary deposits which are directly derived from the primordial. As principal consequences of this fact he points out: 1. The constant existence of copper in the sea waters of ancient and modern times. 2. The origin and mode of formation of copper ores. 3. The necessary presence of copper in all the mineral waters of azoic regions.—*Ann. de Chim. et de Phys.* C.

Action of Nitrates on Nitric Acid.—Alfred Ditte finds that metallic nitrates may be divided, in regard to their action in contact with fuming nitric acid, into three well-marked classes: 1. Some dissolve in large quantities and combine with the acid so as to give rise to acid salts well defined. 2. Some, after having been deprived as much as possible of their water of crystallization, dissolve with ease; the solubility increases with the temperature, and in cooling, hydrous nitrates are deposited, but containing less water than the crystals which are formed from the liquid. In this way he has obtained several new hydrates. 3. A third class, the most numerous of all, contains salts which are insoluble, or only slightly soluble, at all temperatures. Potash and soda are placed in different groups. Lithia is ranged with soda; and rubidium, caesium, thallium and ammonium on the side of potash. All the alkaline nitrates are anhydrous except that of lithia, which crystallizes with five equivalents of water below 10°C. (50°F.), and that of soda, which forms below 0°C. (32°F.) a hydrate containing fourteen equivalents of water.—*Ann. de Chim. et de Phys.* C.

Swiss Anthracite.—Late analyses of the anthracite coal of Valois show about 90 per cent. of carbon and hydrogen and $8\frac{1}{3}$ per cent. of ashes. Experiments with American heaters show that it is capable of replacing the Pennsylvania coal, which is sometimes imported at great cost. It has also been tried successfully in locomotives.—*Les Mondes.* C.

Modifications in the Composition of the Atmosphere.—Ph. Jolly has made numerous analyses of the air near Munich, which show a variation in the percentage of oxygen dependent upon the direction of the wind. When the wind is N. or N. W., the percentage is about 20·92; when it is S. E., S. or S. W., the percentage is only 20·56.—*Les Mondes.* C.

Gas in Metallurgy.—The report of the use of gas from natural springs, in some American puddling furnaces, is attracting the attention of European metallurgists. At the *fontaine ardente* of Saint-Barthélemy, in France, there is a natural gas-well which has been allowed to run to waste for centuries. Preparations have been lately made to make some economical use of this apparently inexhaustible supply, and some sanguine hopes have been expressed that it may convert the province of Dauphiné into a French Pennsylvania.—*Chron. Industr.* C.

Influence of Shape upon Attraction.—C. Lagrange refers to the following proposition, which he demonstrated two years ago: "When attraction varies inversely as the squares of the distance, if the distance is considerable, any mass acts with maximum, mean and minimum energies, in three rectangular directions which are respectively the axes of minimum, mean, and maximum inertia." From this proposition he deduces the following results: "1. A mass of any form, at a certain definite distance from its centre of inertia, acts with maximum, mean and minimum energies, in three rectangular directions which coincide respectively with the three axes of minimum, mean and maximum inertia. 2. The relative positions of a point and of a material system, submitted to their mutual attraction, are determined by the stable axes of equilibrium in the system; the axes of minimum, mean and maximum inertia are respectively axes of stable equilibrium, stable in one plane and unstable in a perpendicular plane, or unstable." The first of these deductions he regards as fundamental in the mechanical theory of crystallization.—*Acad. Roy. de Belg.*

Network of the Photosphere.—Lamey having asserted that he had observed the photospheric network on the solar disk with a six inch telescope, Janssen states that he must have mistaken the willow leaves or rice grains for the phenomenon in question. The photospheric network is made up of the collection of points where the solar granulation is modified, in such minute details that they can be seen only by large instruments with powerful eye-glasses. Under these circumstances the field of view is so limited that it is impossible to embrace a sufficient extent of surface to show the network. It becomes visible only upon very large instantaneous photographs.—*Comptes Rendus.*

Book Notices.

A PRACTICAL TREATISE ON THE COMBUSTION OF COAL, including Descriptions of various Mechanical Devices for Economic Generation of Heat by the Combustion of Fuel, whether Solid, Liquid or Gaseous. By William M. Barr. Yohn Brothers, Indianapolis, Ind., Publishers. 1879.

This book seems to be intended to give, in a small space, the theory of the combustion of coal to those who cannot readily follow the various technical works on the subject. It treats on the physical properties of coal, the atmosphere, various fuels, analyses of coal, combustion and the products of combustion, heat, etc.; construction of furnaces, methods of firing, spontaneous combustion of coal, coal dust as a fuel, petroleum as a fuel, ordinary gas, etc. It presents a compilation of existing knowledge on its various subjects, including nearly all that any one but the technical student will desire to read, and in such shape as to be easily understood. Where it touches on theoretical chemistry it is not so complete as to enable one to thoroughly understand the "why" of the several phenomena talked of or steps described, as in the analysis of coal for example. Again, on the subject of liquid fuel and gaseous fuel there is very little comparison of opinion or discussion. A valuable essay of Rankine, published in the United Service Institution Transactions, being lacking on liquid fuel for example. Something, however, will be found on every point that will probably arise in every-day practice, and what there is is in an excellent form for ready reference.

In addition to this, it may be generally stated that there is no *single book* in English which gives so much in regard to the combustion of coal. Everything in the book is useful, and is written in a form which cannot be complained of as regards simplicity of presentation.

D.

LABORATORY TEACHING: OR PROGRESSIVE EXERCISES IN PRACTICAL CHEMISTRY. By Charles Loudon Bloxam. 4th edition, with 89 illustrations. 12mo. Philadelphia: Lindsay & Blakiston. 1879.

This work, which is well known to teachers of chemistry, first made its appearance in 1869. It is a departure from the old method of teaching analytical chemistry, very commonly followed yet, in that, instead of requiring the student to study and memorize the several reactions of the metallic and non-metallic bodies before proceeding to examine an unknown substance, the author seeks to familiarize the learner with the subject by a series of progressive exercises or lessons, accompanied by examples for practice. The author does not pre-suppose any chemical knowledge on the part of the pupil, and directions for the use of the tables, for performing the various chemical manipulations, are found given where the pupil requires to know them. The book is highly practical throughout, and its scope is well indicated by its title.

W.

LECTURES ON POPULAR AND SCIENTIFIC SUBJECTS. By the Earl of Caithness, F.R.S. 12mo. London: Trübner & Co. 1879.

These lectures, delivered by their author at various times and places, are eight in number, and comprise in this second enlarged edition quite a variety of subjects, those on coal and the steam engines being the most interesting. In the former it is stated that the total available deposits in the British coal fields, at depths not exceeding 4000 feet, and in seams not less than one foot thick, is 90,207,285,398 tons, and taking into account seams which may yet become available, lying under the Permian, New Red Sandstone, and other superincumbent strata, this estimate is increased to 146,480,000,000 tons, which, at the present annual rate of production throughout Great Britain—namely, 123,500,000 tons—would last 1186 years. The United States is credited with having 120,000 square miles of workable coal beds, and peat bogs of considerable extent, in which a substance exactly resembling cannel coal has been found.

The lecture on the steam engine is a brief history of some of the important steps which led to this wonderful invention, and, although it does not contain anything which has not been said often before, yet will be found, like all of the lectures, to be presented in a popular and pleasing style. In conclusion, we desire to call attention to the beautiful printing of this book from the "Ballantyne press." J. B. Lippincott & Co. have also their name on the title page. N.

BRAIN WORK AND OVER WORK. By Dr. H. C. Wood. 16mo. Philadelphia; Presley Blakiston. 1880.

We welcome heartily each addition to the series of American Health Primers, so ably edited by Dr. W. W. Keen, and this latest one is of the utmost importance, for nothing can be more sad than to see a man of fine intellectual endowments breaking down from the vain attempt to do two days' work in one, as so many Americans are trying at the present time.

The author has divided his little book into seven chapters, and after showing in his introductory one the alarming increase of nervous disorders, he gives the general causes of them in another, while the remainder of the treatise is taken up with a discussion of the effects of emotional and intellectual work—the proper age for labor, woman's work, rest in labor and in sleep, necessary recreation, in which the vexed Sabbath question enters, and the plan so strongly advocated by Dr. Mitchell of "camping out." We trust, in conclusion, that this little book will find many readers, and they will profit by the excellent advice Prof. Wood gives. N.

THE WORKSHOP COMPANION; a Collection of Useful and Reliable Recipes, etc., for the Household and Shop. 16mo. New York: Industrial Publication Co. 1879.

This is an enlarged edition of a little Pocket Manual, known as the Amateur's Handbook, and contains quite a variety of recipes, many of which have been long known and found to be of decided value. The practical hints are in many cases excellent, and in addition to the matter contained in the book being arranged alphabetically, we have also what no volume should be without, a very full index.

N.

Electric Transmission of Power: Its Present Position and Advantages. By Paget Higgs, LL.D. 12mo. London: E. & F. N. Spon. 1879.

In this little work on a subject which is attracting at the present time a great deal of attention from scientific men, the author has collected the best data that he could find to prove that it has a wide field of usefulness before it, and after describing briefly the Gramme, Brush, Wallace-Farmer and Siemens machines, a chapter is given on their efficiency, and its applicability to long and short circuits. Use is made largely of the very valuable report of Profs. Houston and Thomson on Dynamo-electric Measurements, published by the Institute, and which has become such an authority, and the investigations of Siemens, Mascart and Hopkinson are referred to. Despite many faults, that would have been perhaps avoided by Dr. Higgs if the Horatian rule of waiting ten years had been observed, the work can be read with profit by almost every one. N.

The Microscope in Medicine. By Lionel S. Beale, M.B., F.R.S. Fourth edition, much enlarged. 8vo. London, 1878, also Philadelphia: Presley Blakiston. 1878.

We have before us the fourth edition of Prof. Beale's work, "The Microscope in Medicine," a book which it gives us pleasure to recommend for careful study to every student of microscopy, whether he be a physician or naturalist. He will find in it not only a clear exposition of the methods employed in order to obtain the best results in microscopical examination of tissues, but also a description, profusely illustrated with drawings by the author's own hand, of the histological details of tissues as seen under the microscope.

In the first chapter we find full directions given of how to employ the different necessary accessory instruments; how to use reagents in order to develop certain details; how to examine objects; how to measure them, and to make records by means of drawings upon paper, wood and other materials.

The second chapter is devoted to the consideration of hardening soft tissues, and methods are given for removing the earthy salts from bone, so that sections may be cut.

The third, fourth and fifth chapters contain directions for cutting ections of hardened tissues, and for staining them so as to differentiate the histological details as well as for permanently mounting preparations.

The sixth chapter treats of the different methods employed to reveal the vascular system in healthy as well as morbid tissues by means of injecting, and will prove to the readers one of the most interesting parts of the book.

In the seventh chapter the author gives a concise description of his method of preparing tissues for microscopical examination, which is an excellent one if a certain class of work is desired by the student, but which does not give equally good results in all cases.

The second part of the book is devoted to the description of tissues when prepared and viewed under the microscope, and thus forms a source of information to every one interested in the minute anatomy of animal organisms.

The last two chapters give full directions of how to obtain crystals from animal fluids, and of how to conduct spectrum analysis by means of the spectrum microscope.

The book is profusely illustrated, containing over 500 engravings, most of which are drawn to a scale so that forms seen in the microscope may be compared with them, not only in regard to shape, but also in regard to size.

The great value of the work consists in the fact that the author has worked the different processes and given them a fair trial, and recommends only those which by personal experience he has found to be reliable, so that the student, if he closely adheres to the directions given, will be sure to succeed. S.

Franklin Institute.

HALL OF THE INSTITUTE, Feb. 18th, 1880.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 148 members and 81 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that eight persons were elected members of the Institute at their last meeting. Also that two vacancies existed in the Board, caused by the election of Mr. Henry Cartwright as Vice-President, and Dr. Norris as Secretary.

The following donations to the Library are reported by the Secretary:

Specifications and Drawings of Patents from Sept. 26th to Dec. 31st, 1878, and Jan. 1st to 9th, 1879.
From the Commissioners of Patents. London.

Holtzapffel's Turning and Mechanical Manipulation. Vol. 4.
From the Author.

On the Fixed Signals of Railways, by R. C. Rapier.
Railway Materials. Catalogue, by Ransome & Rapier.
From Fred'k Ransome.

Specifications and Drawings of American Patents for August and September, 1879. From the Patent Office. Washington.

Reports on Experiments in Boiler Bracing.
From the Bureau of Steam Engineering, Navy Dep't, Washington.

Biographical Sketch of William Penn.
From the Historical Society of Penna.

Annual Report of the Chief of Ordnance to the Secretary of War for 1879.
Ordnance Memorandas Nos. 1, 2, 4 to 10, 12 and 13.
From the Chief of Ordnance. Washington.

Annual Report of the Secretary of the Treasury on the state of the Finances for the year 1879.
Annual Reports of the Director of the Mint to the Secretary of the Treasury for 1873, 1875 to 1879.
From the Secretary of the Treasury.

Ninth Annual Report of the Trustees of the State Industrial School for Girls, of State of New Jersey, for 1879. From R. Bingham.

Thirty-fourth Annual Report of the Director of the Astronomical Observatory of Harvard College. By E. C. Pickering. Cambridge, 1880.
Annual Report of the Supervising Inspector-General of Steam Vessels to the Secretary of the Treasury for 1879.
From the Supervising Inspector.

Documents relative to the Colonial History of the State of New York, by E. B. O'Callaghan. Vol. 9.
From the State Library, Albany.

Centenary of the Birmingham Library, 1779.
From I. Norris, M. D.

Mr. George S. Strong read the paper announced for the evening, on "Incrustations and Scale in Boilers."

In introducing his subject, he said that while a great deal of attention had been given to perfecting the engine, too little attention had been paid to the evaporative power of boilers. It is a fact recognized by the best engineers that a scale of one-sixteenth of an inch causes a loss of twenty per cent. in the evaporative power of a boiler, and the increase in loss is very rapid as the thickness of scale increases.

He ventured the opinion that eighty per cent. of the boilers in the country have a scale of from one-sixteenth to half an inch, and even more. The difficulty arises from vegetable and earthy matter held in suspension, and solid matter held in solution. These, becoming heated, are precipitated and settle to the bottom and sides of the boiler or in flues and tubes where these are used. When there is only mud and vegetable matter in the water, the deposits can be blown out and the boiler thus kept clean. But where there is mineral matter in the water, which is generally the case, it becomes a most difficult matter to keep the boiler clean.

Mr. Strong described the mineral deposits made on boilers. The most common and dangerous of these is sulphate of lime. It is precipitated by heat in small crystals or flakes, which, after forming a thin, hard scale, breaks off and forms again in bunches, making the boiler liable to be burned, especially if fired with soft coal. A high degree of temperature, 290 degrees Fahr., is required to precipitate the sulphate of lime. Carbonate of lime, magnesian lime, oxide of iron, alumnia and sulphuric acid are also sometimes found in water and form scales, giving great trouble. They are all precipitated by heat generally of 212 degrees Fahr.

A number of photographs were exhibited by the lantern in connection with this subject, and the paper was discussed by Messrs. Cooper, Cartwright and Orr.

The Secretary read a short paper describing the "Burgess Portable Mechanical Blowpipe," and the various attachments for different purposes.

This is a simple and efficient device for maintaining a continuous supply of air for blowpipe use. The general appearance of the blowpipe was shown by engravings. The pump cylinder is mounted on an arched stand, and contains a piston having a valve opening upward. The piston is connected with the foot pedal by a forked connecting rod, and is moved by a slight and easy motion of the foot.

The upper end of the pump cylinder is closed, with the exception of a valve aperture, which is covered by a valve opening upwards into a cylindrical air reservoir secured to the upper end of the pump.

Near the top of the air reservoir there is a nipple to which is attached a flexible tube communicating with the blowpipe. The pipe outlet is much smaller than in the mouth blowpipe, to permit of maintaining a pressure, which may be increased or diminished by a quick or slow motion of the treadle. The air chamber is easily filled, and when charged affords a *constant* supply of pure air. The machine is light and portable, weighing but twelve pounds, and measuring 24 inches in height. The pump cylinder is 2½ inches in diameter, with 3 inch stroke. For light and delicate work, when a gentle flame is required, a pressure of one or two pounds is given, but for brazing, annealing, fusing, etc., when a large flame is necessary, a few rapid strokes of the plunger will raise the pressure in the receiver to from 10 to 12 pounds, which can be sustained with but little exertion.

Mr. J. Elliott Shaw gave an exhibition of its power in the melting of hard spring brass and other refractory metals.

One of Edison's electric lights was then shown, for the first time in this country outside of Menlo Park, and it was kindly obtained for the Institute by Mr. Addison B. Burk. It was mounted on a statuette representing Mercury, and an attempt was made to light it by means of the Brush dynamo-electric machine belonging to the Institute. The carbon was raised to a white heat until the lamp gave forth a light greater than the average one furnished by the lamps at Menlo Park.

Mr. Burk, to whom the lamp had been given by Mr. Edison, said that the machine in use was not suited to the lamp, and that Mr. Edison had warned him that this was the case, but as there was great curiosity to see the lamp, he had determined to attempt to show it. The light was maintained for five or ten minutes, and then the current increasing rapidly, apparently burnt out the connections, and in a moment the lamp was broken.

Mr. Burk reported that at his last visit to Menlo Park he had found workmen engaged in putting up a building to be used as a model of a central office, in which are to be placed twenty generators. Mr. Edison expects, when the building is completed, to be able to demonstrate the cheapness of the light. He is at present engaged in experimenting with various natural fibres in place of paper, but considers the carbon from paper entirely satisfactory. The horse-shoes are not now made from cardboard, but from pure paper made for the purpose without admixture of kaolin with the cellulose. One of the lamps at Menlo Park had been burning 804 hours on Saturday, and seven 720 hours, while the others were of varying age, from several hundred to a few hours.

Inquiries were made as to the horse-power employed in running the dynamo-machine which furnished the light, apparently with the view of ascertaining its cost, but Prof. Houston explained that the engine and machine would undoubtedly maintain several such lights.

Two Brush electric lights were then exhibited. The lamps are made on a new principle, and maintained a very steady light. Prof. Houston explained the difference between the light from incandescence, as shown in the Edison lamp, and the light from the volatilization of carbon in the voltaic arc, as in the Brush lamps.

The Secretary's report included an account of the Tapley Letter File, Burns' Security Sash Locks, Longaker's Liquid Measuring Can, for coal oil, etc., Eldridge's "Sautophone," an instrument to assist the hearing of persons, and the "Waterbury Watch." By the aid of the megascope, the latter was shown on a large scale upon the screen, the movement being distinctly seen. Papers were read, on Steel Vessels; the Microscopic Detection of Arsenic; the Machinery for the Removal of the Cleopatra Needle; on the Use of the Telephone in Europe; Electric Lights at Sea; the Bursting of the English 100-ton Gun; the Tay Bridge Disaster; the Cental System; the "Topophone;" and Modifications of the Audiphone.

The invitation of the Board of Managers to Mr. A. E. Outerbridge, Jr., of the United States Mint, requesting him to repeat his two lectures on the "Art of Coining," etc., in a larger hall than that of the Institute, was read by the Secretary, and Mr. Outerbridge's acceptance of the same, with his suggestion that the proceeds be devoted to the Library Fund.

Nominations for Managers being announced as in order, Mr. Henry Cartwright proposed Mr. Frederick Graff and Mr. W. L. Dubois. No others being offered, Mr. Weaver moved that the nominations be closed, which was carried, and tellers being appointed, the Secretary was directed to cast the vote of the Institute for the gentlemen named, and they were declared by the President duly elected.

On motion, the meeting adjourned.

ISAAC NORRIS, M. D., *Secretary.*

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NAVAL ARCHITECTURE.

By CHAS. H. HASWELL, C. and M. E.

No. 1.

RESULTS OF EXPERIMENTS UPON THE FORM OF VESSELS.

[Wm. Bland.]

Cubical Models.

Head Resistance.—Increases directly with the area of its surface.

Resistance to Weight.—Increases directly as the weight.

Vessel's Models.

Lateral Resistance.—About one twelfth of the length of the body immersed, varying with the speed.

Order of Superiority of Amidship Section.

Rectangle, Semi-circular, Ellipse and Triangle.

The centre of lateral resistance moved forward as the model progressed.

The centre of gravity had no influence upon the centre of lateral resistance.

RELATIVE SPEEDS.

Length.—Increased length gave increased speed or less resistance.

Depth of Flotation.—Less depth a vessel can be borne upon water, less the resistance.

Amidship Section.—Curved sections gave higher speed than angled.

Sides.—Slight horizontal curves present less resistance than right lines.

Curved sides with one-fourth more beam gave equal speeds with straight sides of less beam.

Keels.—Length of keel has greater effect than depth.

Stern.—Parallel-sided after body gave greater speed than a taper-sided.

Form of Bow.	Order of Speed.
Isosceles triangle, sides slightly convex, . .	1
" " " right lines. . . .	2
" " " slightly concave at entrance and running out convex, ...	3

Spherical equilateral triangle compared to *Equilateral triangle*, speed was as 11 to 12. *Equilateral triangle*, with its isosceles sides, was as 5 to 4.

When bow had an angle of 14° with plane of keel, compared with one of 7° its speed was greater.

Bodies Inclined Upward from Amidship Section.

1. Model with bow inclined from "dead flat," had less resistance than model without any inclination.

2. Model with stern inclined from "dead flat," had less resistance than model without any inclination.

Model 1 had less resistance than model 2. Model with both bow and stern inclined from "dead flat," had less resistance than either 1 or 2.

By experiments of Mr. Froude, resultant speed at different velocities, in case of two large vessels, was as follows:

4 knots, . .	·6 . .	1·
6 " . . .	1·4 . . .	2·3
8 " . .	2·5 . .	3·9
10 " . . .	4·7 . . .	6·
12 " . .	9· . .	9·

STABILITY.

With equal lengths, ratio of stability is at its limit of rapid increase when width is one-third of length, being nearly in cubic ratio, afterwards it approaches to arithmetic ratio.

Results of Experiments upon the Stability of Rectangular Blocks of Wood of Uniform Length and Depth, but of Different Breadths.—[W. Bland.]

(Length 15, Depth 2, and Depression 1 inch.)

Width.	Weight.	Ratio of Stability.			
		As Observed.	With like Weights.	By Squares of the Widths.	By Cubes of the Width.
Ins.	Oz.				
3·	24	1·	1·	1·	1·
4·5	35	2·5	2·4	2·25	3·375
6·	45	7·	3·7	4·	8.
7·	55	11·	4·8	6·25	15·625

Hence it appears, that rectangular and homogeneous bodies of a uniform length, depth, weight and immersion in a fluid, but of different widths, have stability for uniform depressions at their sides (heeling) nearly *as the squares of their width ;* and that, when the weights are directly as their widths, their stability under like circumstances is nearly *as the cubes of their width.*

Results of Experiments upon the Stability and Speed of Models having Amidship Sections of Different Forms, but of Uniform Length, Width and Weights.—[W. Bland.]

(Immersion different, depending upon form of Section.)

Form of Immersed Section.	Stability.	Speed.
Half-depth triangle ; the other half rectangle,	12·	4·
Rectangle, ...	14·	3·
Right-angled triangle,* . .	7·	3·
Semicircle, ...	9·	2·

---

* Draught of water or immersion double that of the rectangle.

BOTTOM AND IMMERSED SURFACE OF HULL OF VESSELS.

TO COMPUTE THE EXTERNAL OR BOTTOM AND SIDE SURFACE OF THE HULL OF A VESSEL.

Bottom and Side. RULE.—Multiply the length of the curve of the amidship section, taken from the top of the tonnage or main deck beams upon one side to the same point upon the other (omitting the width of the keel), by the mean of the lengths of the keel and between the perpendiculars in feet, and multiply the product by ·85 or ·9 (according to the capacity of the vessel), and the product will give the surface required in square feet.

EXAMPLE.—The lengths of a steamer are as follows: Length of keel 201 feet, and between the perpendiculars 210 feet; length of the curved surface of the amidship section 76 feet. What is the surface? Coefficient assumed ·87.

$\overline{210+201} \div 2 = 205{\cdot}5$, and $76 \times 205{\cdot}5 \times {\cdot}87 = 13{,}587$ square feet.

NOTE.—The exact surface as measured was 13,650 square feet.

Bottom Surface.—RULE.—Multiply the length of hull at the load line by its breadth, and this product by the depth of the immersion, (omitting the depth of the keel) in feet; and this product multiplied by from ·07 to ·08 (according to the capacity of the vessel) will give the surface required in square feet.

EXAMPLE.—The length upon the load line of a vessel is 310 feet, the beam 40 feet, the depth of the keel 1 foot, and the draught of water 20 feet; what is the bottom or wet surface?

Coefficient assumed ·073.

$$310 \times 40 \times \overline{20-1} \times {\cdot}073 = 17{,}199 \text{ square feet.}$$

TO COMPUTE POWER REQUIRED IN A STEAM VESSEL, CAPACITY OF ANOTHER VESSEL BEING GIVEN.

In vessels of similar models,

$$\frac{v\,A}{a} = V;\quad \frac{S^3\,V}{s^3} = V';\quad \frac{V'\,r'}{r} = C \text{ and } \frac{C}{2\,r} = R.$$

v representing product of volume of given cylinder and revolutions in cube feet, a and A, areas of immersed section of given and required vessel at like revolutions and speed of given vessel in cube feet, s and S, speeds of given and required vessel at revolutions of given vessel in cube feet, r and r′, revolutions of given and required vessel, and C, product of volume of combined cylinder and revolutions for required vessel.

Illustration.—A steam vessel having an area of amidship section of 675 square feet, has two cylinders of a combined capacity of 533·33 cube feet, and a speed of 10·5 knots per hour, with 15 revolutions of her engines. Required volume of steam cylinders, with a stroke of 10 feet, for a section of 700 feet and a speeed of 13 knots with 14 revolutions.

$v = 533·33 \times 15 = 8000$ cube feet, $\frac{8000 \times 700}{675} = 8296·3$ cube feet.

$\frac{13^3 \times 8296·3}{10·5^3} = 15{,}745·2$ cube feet, $\frac{15 + 15{,}745·2}{14·5} = 16{,}288.1$ cube ft., and $\frac{16{,}288·1}{2 \times 14·5} = 566·66$ cube feet, which ÷ 10 stroke of piston, 12 for inches and × 1728 for inches in a cube foot $= \frac{561·66 \times 1728}{10 \times 12} = 8087.9$ square inches area of each cylinder = diameter of 101·5 inches.

APPROXIMATE RULES TO COMPUTE SPEED AND INDICATED HORSE POWER OF STEAM VESSELS.

$$\frac{V^3 D^{\frac{2}{3}}}{IHP} = C; \quad \sqrt[3]{\frac{C\,IHP}{D^{\frac{2}{3}}}} = V; \text{ and } \frac{V^3 D^{\frac{2}{3}}}{C} = IHP$$

$$\text{or } \sqrt[3]{\frac{C\,IHP}{A}} = V; \text{ and } \frac{V^3 A}{C} = IHP.$$

C representing coefficient of vessel, A area of immersed amidship section, V velocity of vessel in knots per hour, and D displacement of vessel in tons.

Note.—When there exists rig, an unusual surface in free board deck houses, etc., or any element that effects coefficient for the class of vessel given, a corresponding addition to, or decrease, or addition of the following units is to be made:

Range of Coefficients as deduced from observation is as follows:

				C.	
Side Wheel.	A	D	V	$\frac{V^3 A}{IHP}$	$\frac{V^3 D^{\frac{2}{3}}}{IHP}$
	Sq. ft.	Tons.	Knots.		
River steamboat medium lines,	43	73	10	470	212
" " " "	150	465	13	570	219
" " fine "	136	300	19	540	200
Sea steamer medium full lines,*	675	3600	10	650	214
" fine lines,†	550	5233	15	650	211

* Full rigged. † Bark rigged.

SCREW PROPELLER.	A	D	V	C $\frac{V^3 D^{\frac{2}{3}}}{IHP}$	$\frac{V^3 A}{IHP}$
	Sq. ft.	Tons.	Knots.		
River steamboat medium lines,	45		12	500	
" " fine "	150		15	530	
Torpedo boat " "		27	20	500	170
Sea steamer medium full lines,*	550	2532	9	570	194
" " " " *	390	1475	10	470	180
" fine lines		3660	13		210

Coefficients as Determined by Several Steamers of H. B. M. service.
(C. Mackrow, M. I. N. A.)

Length.	$\frac{\text{Length}}{\text{Beam.}}$	Area of section at 0.	Displacement.	$IHP.$	Speed.	$\frac{V^3 A}{IHP} =$
Feet.		Sq. ft.	Tons.		Knots.	
185	6·53	236	775	782	10·34	333
212	5·89	377	1554	1070	10·89	456
360	7·33	814	5898	2084	11·5	598
270	6·43	632	3057	2046	12·3	574
380	6·52	1308	9487	3205	12·05	714
400	6·73	1198	9152	5971	13·88	536
362	7·33	778	5600	3945	14·06	548
400	6·73	1185	9071	6867	15·43	634

PROPORTION OF POWER UTILIZED IN A STEAM VESSEL.

SIDE WHEEL.

$\frac{P - z}{\cdot00000259 \times d^3 \times r^2} = C.$ *P representing gross Indicated Horse-Power, z, loss of effect by slip and oblique action of wheel (or propeller), d, diameter of wheels at centre of effect, r, revolutions per minute, and C, coefficient for the vessel.*

Illustration.—The indicated horse-power of the engines of a side-wheel steamer is 1120; the slip of the wheels and loss by oblique action, 33·37 per cent.; the diameter of the centre of effect of the wheels is 29·5 feet, and the number of revolutions 13·5 per minute; what is the coefficient, and what the power applied to propel the vessel?

Note.—The slip of the wheels from their centre of effect in this case is 15·37 per cent., and the loss by oblique action 18 per cent. Hence, representing the total power by 100, 100 — $(18+15{\cdot}37) = 66{\cdot}63$ per cent. of the power applied to the wheels.

---

* Full rigged.

As the assumed power that operates upon the wheels in this case is taken at 86·12 per cent. of the power exerted by the engines, $86{\cdot}12 \times 22{\cdot}37 = 28{\cdot}74$ per cent. for the sum of loss by the wheels.

$$\frac{1120 - (1120 \times 28{\cdot}74 \div 100}{{\cdot}00000259 \times 29{\cdot}5^3 \times 13{\cdot}5^2} = \frac{798{\cdot}11}{12{\cdot}16} = 65{\cdot}53 \text{ coefficient.}$$

The speed of the vessel being 10 knots per hour = 17·05 feet per second, the power applied to propel the vessel at this speed = $65{\cdot}63 \times 17{\cdot}05^2 = 19{,}076{\cdot}13$, and the horse-power exerted =

$$\frac{19{,}076{\cdot}13 \times 17{\cdot}05 \times 60}{33{,}000} = 591{\cdot}36 \text{ horses-power.}$$

Side Wheel.

	Horse-power.	Per cent. of power.
Friction of engines 1·5 lbs. upon 3848 sq. ins. × 13·5 revolutions × $\overline{10 \times 2} \div 33{,}000 \times 2 =$	94·45	18·83
Friction of load 6 per cent. upon pressure of steam, less the 2 lbs. for friction of engine, as above =	60·45	
Oblique action of wheels =	201·6	18·
Slip of wheels =	172·14	15·37
Absorbed by propulsion of vessel	591·36	52·8
	1120·	100·

Screw Propeller.

	Horse-power.	Per cent. of power.
Friction of engines =	96·06	18·83
" of load =	81·48	
" of screw surface and resistance of edges of blades =	53·44	6·83
Slip of propeller =	205·55	26·27
Absorbed by propulsion of vessel	375·92	48·04
	782·45	100·

From experiments of Mr. French,* he deduced that, as a rule, that only 37 to 40 per cent. of whole power exerted was usefully employed.

With an auxiliary propeller, essential differences are in friction of surfaces and edges of blades of propeller and slip of propeller, being as 12 to 6·83 in excess in first case, and as 13·7 to 26·27 in second case, or 50 per cent. less.

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* Transactions of Institution of Naval Architects, vol. xvii.

TO COMPUTE THE RESISTANCE TO THE WET SURFACE OF THE HULL OF A VESSEL.

$C\,a\,v^2 = R$. *C representing a coefficient of resistance, a area of wet surface in square feet, and v velocity of hull in feet per second.*

Values of C,		
	·007, clean copper.	·014, iron plate.
	·01, smooth paint.	·019, iron plate, moderately foul.

The power required to propel one square foot of immersed amidship section at "dead flat" is ·073 that of smooth wet surface.

ELEMENTS OF CAPACITY AND SPEED OF SEVERAL TYPES OF STEAMERS OF R. N. (W. H. White.)

Classes.	Length.	Length to Breadth.	Displacement.	Speed.	I. H.-P. to Displacement.	I. H.-P. to Displacement $\frac{2}{3}$
Iron Clads.	Feet.		Tons.	Knots.		
Early types	380 to 400	6·5 to 6·75	9000 to 10500	14· to 14·5	·6 to ·7	11 to 11
Recent "	300 to 330	5·25 to 5·75	7500 to 9000	14· to 15·	·9 to 1·	16 to 20
" twin screws	280 to 320	4·5 to 5·	6000 to 9000	14· to 15·	·7 to ·9	15 to 1
Unarmoured.						
Swift cruisers	270 to 340	6·5 to 6·75	3000 to 5500	15· to 16·	1·3 to 1·5	20 to 24
Corvettes	200 to 220	6	1800 to 2000	12·75 to 13·25	1· to 1·2	13 to 14
Sloops	160	5	850 to 950	11	1· to 1·2	10 to 11
Gun vessels	125 to 170	5·5 to 6·25	420 to 800	9·5 to 11·	·8 to 1·4	7 to 11
Gun boats (coast)	80 to 90	3· to 3–25	200 to 250	8· to 9·	·8 to 1·1	5 to 7
Merchant.						
Mail, large	400 to 500	9· to 11·	7000 to 10000	14· to 15·	·5 to ·6	10 to 11
" smaller	300 to 400	8· to 10·	5000 to 7000	13· to 14·	·4 to ·5	7 to 10
Cargo, large	250 to 350	7·5 to 10·	3000 to 6000	11· to 15·	·3 to ·5	5 to 9
" smaller	200 to 300	7· to 9·	1500 to 4000	9· to 11·	2 to 2·4	3 to 6

TO COMPUTE ELEMENTS OF A VESSEL.

DISPLACEMENT AND ITS CENTRE OF GRAVITY.

Displacement of a vessel is volume of her body below water-line, or line of immersion.

Centre of Gravity, or Centre of Buoyancy of Displacement, is centre of gravity of water displaced by hull of vessel.

For Displacement. RULE.—Divide vessel, on half breadth plan, into a number of equidistant sections, as one, two or more frames, commencing at "dead flat" and running each side of it. Add together lengths of these lines in both fore and aft bodies, except first and last, by by Simpson's rule for areas; multiply sum of products by one-third distance between sections, and product will give area of water-line between fore and aft sections.

Then compute areas contained in sections forward and aft of sections taken, including stern and rudder post, rudder and stem, and add sum to area of body sections already ascertained.

Compute area of remaining water-lines in like manner.

Tabulate results, and multiply them by Simpson's rule in like manner as for a water-line, and again by consecutive number of water-lines, and sum of products between water-line, and product will give volume between load and lower water-line.

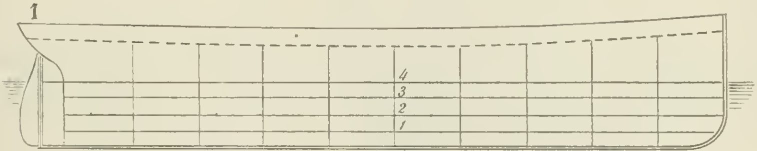
Add area of lower water-line to area of upper surface of keel; multiply half sum by distance between them, and product will give volume. Compute areas contained in sections forward and aft of sections taken as before directed.

If keel is not parallel to lower water-line, take average of distance between them.

Compute volume of keel, rudder post and rudder below water-line, add to volume already ascertained, multiply product by two, for full breadth, and product will give volume required in cubic feet, all dimensions being taken in feet.

EXAMPLE.—Assume a vessel 100 feet in length by 20 feet in extreme breadth, on load-line of 8 feet 9 inches immersion. Figs. 1 and 2.

1



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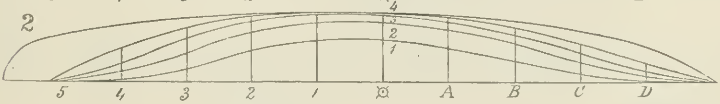

Distance between sections, for purpose of simplifying this example, is taken at 10 feet; usually frames are 18 to 30 inches apart, and two or more included in a section. Water-lines 2 feet apart.

1st Water-line.

4	5·		–	=	5·
3	7·7	×	4	=	30·8
2	9·5	"	2	=	19·
1	9·9	"	4	=	39·6
0	10·	"	2	=	20·
A	9·6	"	4	=	38·4
B	7·8	"	2	=	15·6
C	6·8	"	4	=	27·6
D	4·	"	–	=	4·
					199·6
		10 ÷ 3 =			3⅓
					605·3
Abaft section 4, rudder and post, . .					25·
Forward section D and stem, . .					20·7
					711·

2d Water-line.

4	2·7		–	=	2·7
3	6·9	×	4	=	27·6
2	8·7	"	2	=	17·4
1	9·5	"	4	=	38·
0	9·6	"	2	=	19·2
A	4·	"	4	=	36·
B	7·	"	2	=	14·
C	5·	"	4	=	20·
D	2·	"	–	=	2·
					176·9
		10 ÷ 3 =			3⅓
					589·7
Abaft section 4, rudder and post, . .					13·2
Forward section D and stem, . .					9·1
					612·

3d Water-line.

4	1·5		–	=	1·5
3	5·	×	4	=	20·
2	6·6	"	2	=	13·2
1	8·7	"	4	=	34·8
0	8·9	"	2	=	17·8
A	7·6	"	4	=	34·
B	7·	"	2	=	14·
C	3·	"	4	=	12·
D	1·2	"	–	=	1·2
					144·9
		10 ÷ 3 =			3⅓
					403·
Abaft section 4, rudder and port, . .					7·
Forward section D and stern, . .					5·4
					495·4

4th Water-line.

4	·7		–	=	·7
3	2·	×	4	=	8·
2	4·3	"	2	=	8·6
1	6·5	"	4	=	26·
0	6·8	"	2	=	13·6
A	5·	"	4	=	20·
B	3·6	"	2	=	7·2
C	·9	"	4	=	3·6
D	·3	"	–	=	·3
					88·
		10 ÷ 3 =			3⅓
					293·3
Abaft section 4, rudder and post, . .					3·2
Forward section D and stem, . .					·8
					297·3

Keel.

Half breadth = ·25 × length of 98 feet = .	24·5
Rudder post and rudder, . .	·3
	24·8

RESULTS.

1st water-line,	711·		–	=	711·				
2d "	612·	×	4	=	2448·	×	1	=	2448·
3d "	495·4	"	2	=	990·8	"	2	=	1981·6
4th "	297·3	"	4	=	1189·2	"	3	=	3567·6
Keel,	24·8		–		24·8	"	4	=	99·2
					5363·8				8096·4
					2				
					3) 10727·6				

Displacement, 3575·9 × 2 = 7151·8 cube feet.

FOR CENTRE OF GRAVITY.

RULE.—Divide sum of products obtained as above by consecutive water-lines, by sum of products obtained in column of products by Simpson's multipliers, and quotient multiplied by distance between water-lines will give depth of centre below load water-line.

ILLUSTRATION.—8096·4, from above, ÷ 5363·8 = 1·5, which × 2 = 3 feet.

Or $\dfrac{n}{2\left(2-\dfrac{D}{an}\right)} = d.$ *n representing draught of water exclusive of any drag of keel, a area of immersed surface of hull in square feet, and D displacement in cube feet.*

ILLUSTRATION.—Assume draught of water 8 feet, displacement 7152 cube feet, and area of immersed surface of hull 1100 square feet.

Then $\dfrac{8}{2\left(2-\dfrac{7152}{1100\times 8}\right)} = \dfrac{8}{2\times 1{\cdot}107} = 3{\cdot}37$ feet.

SAWS.

By Robert Grimshaw, Ph.D.

Continued from page 175.

The Circular Saw.—During all the centuries which witnessed the birth and rise, the haughty supremacy and the fall of nations in successive turns, no important change was made for the better in the manufacture of saws, until, in 1790, a device was brought out by Brunel, by which cutting should be continuous. In other words, the application of the rotary principle to power-driven saws was given practically to the world.* While the circular saw was first practically used in Holland, its development is due to England and America—especially the latter.

The circular or "buzz" saw, not having inertia to overcome in revolving, has a higher cutting speed of teeth than the reciprocating. Besides this advantage of continuous cutting.

It is made with solid and with removable teeth. We shall consider the solid-toothed variety first.

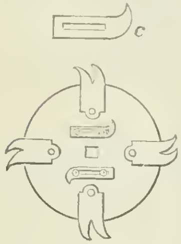

Fig. 40. Eight-toothed Weatherboard Saw.

(From Holzapffel, 1846.)

It consists, in its application to wood cutting, of a circular disk of steel, rolled to even gauge, and then generally ground thinner either in the centre or at the rim, after the teeth are cut.

As a general thing, the teeth of circular saws are more distant, more inclined, and more set, than those of rectilinear. But their action may be referred to the tangent of the circle at each tooth, just as in straight saws to the line of the blade.

---

* The circular saw appears in a British patent of Miller, No. 1152 of 1771. The full text may be found in Richards' work on Wood Working Machines, page 6.

The teeth are more distant, because their great velocity makes their effect almost continuous. In one variety used for cutting feather-edged or weather boards and taking a very deep, wide cut, this is carried to an extreme—there being but eight sectional teeth (see Fig. 40). Fewness of teeth gives the necessary increased throat room for sawdust.

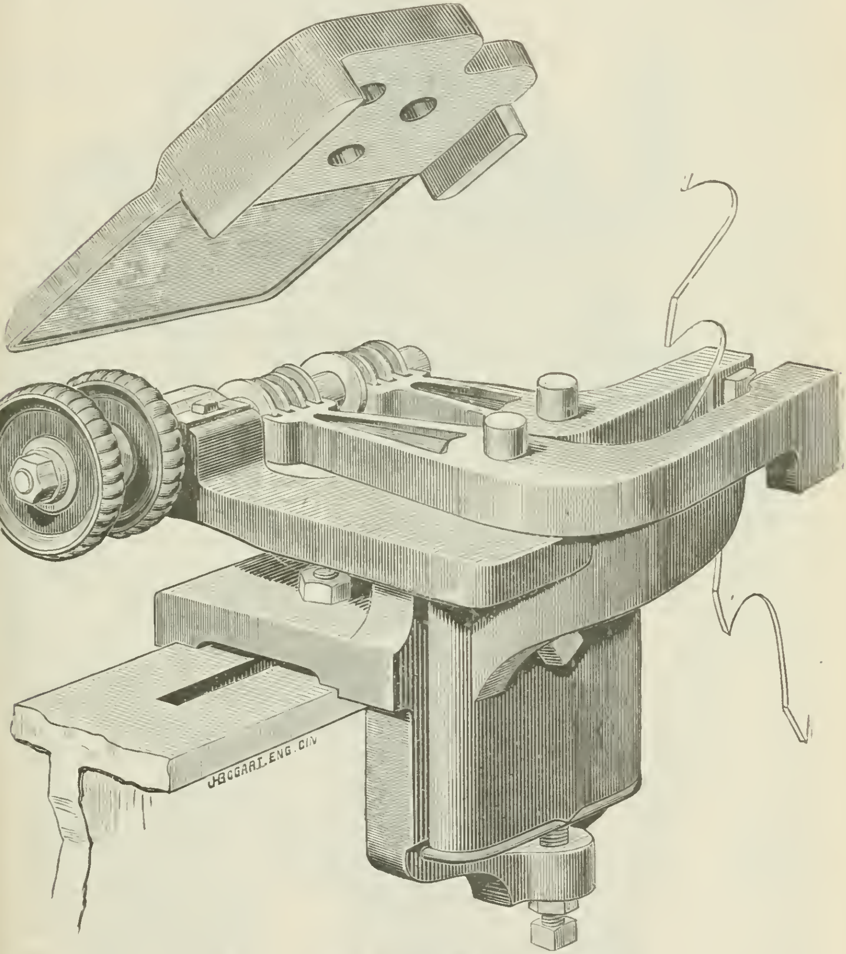

Fig. 41. Lane & Bodley's Side Guide.

Their teeth are more inclined because they have additional power by reason of their great velocity, and hence can stand the extra front rake.

They are more set to make a wider kerf, required by reason of the waving and wabbling at high speeds of the disk, which cannot, of course, even if perfectly homogeneous and true, and unaltered by heat, be kept as rigid as a strained straight blade.*

The circular saw is easily run, and at a high speed. But it requires continuous attendance, the work being so rapidly done as to be in the operator's hands nearly all the time.

Circular saws ordinarily run 9000 to 10,000 feet per minute, or 200 times as fast as a push cut hand saw, which makes about 100 feet per minute, cutting only half the time.

We may say for disks 12 inches diameter, 3000 revolutions per minute; 2 feet diameter, 1500 revolutions; 3 feet, 1000 revolutions; 4 feet, 750 revolutions; 5 feet, 600 revolutions.

Shingle and some other saws, either riveted to a cast iron collar or very thick at centre and thin at rim, may be run with safety at a greater speed. Shingle saws are tapered to 14 or 15 gauge, and run from 30 to 48 inches in diameter. We give herewith a

TABLE OF SPEED FOR CIRCULAR SAWS.

Size of Saw.	Rev. per min.	Size of Saw.	Rev. per min.
8 in.	4500	42 in.	870
10 in.	3600	44 in.	840
12 in.	3000	46 in.	800
14 in.	2585	48 in.	750
16 in.	2222	50 in.	725
18 in.	2000	52 in.	700
20 in.	1800	54 in.	675
22 in.	1636	56 in.	650
24 in.	1500	58 in.	625
26 in.	1384	60 in.	600
28 in.	1285	62 in.	575
30 in.	1200	64 in.	550
32 in.	1125	66 in.	545
34 in.	1058	68 in.	529
36 in.	1000	70 in.	514
38 in.	950	72 in.	500
40 in.	900		

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*Something partly answering the purpose of straining is gained by the "side guides" of large circular saws. See Fig. 41.

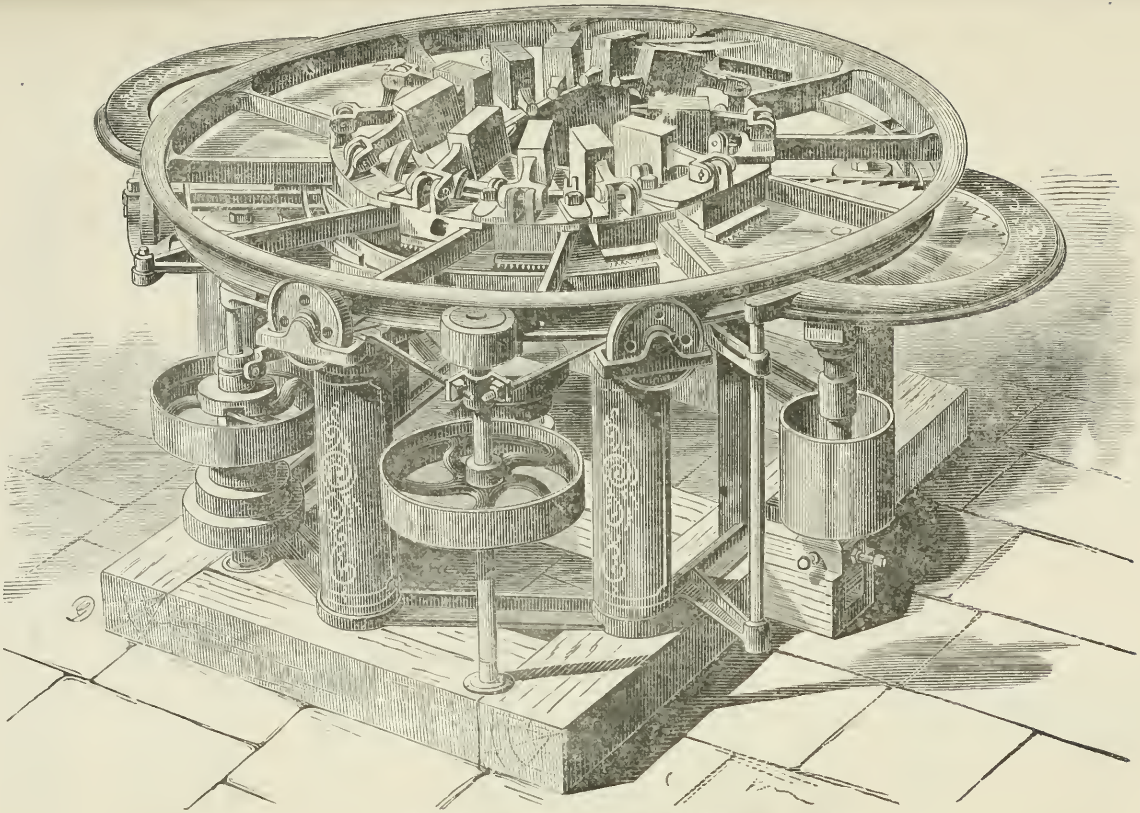

Fig. 42. Largest Shingle Machine in the World.

Richards, in his “Operator's Handbook,” gives the following speeds for circulars:

Diam.	R. P. M.	Peripheral Velocity. Feet per min.
36 inches,	1500	14,100
30 “	1800	14,100
25 “	2100	13,700
20 “	2400	12,500
15 “	2700	10,600
10 “	3000	7,000

For shingle making the circular saw is sometimes run horizontally, as illustrated in Fig. 42, which shows the largest shingle machine in the world.

A shingle saw should be re-ground as soon as it wears down to 14 gauge, as the thinner the saw used the more profit. It does not pay to cut timber into sawdust instead of shingles.

Simonds' 36-inch shingle saws (said to be not hammered) make from 1925 turns per minute, and 116 clips, up to 2200 revolutions.

The circular saw should not be used on work thicker than one-third the saw diameter. A 20-inch square “cant” or log would necessitate a 60-inch circular saw, which may be $\frac{7}{32}$ inch thick and make a kerf of $\frac{9}{32}$ inch. But some economy of kerf and hence of time, power and material is gained by the “double circular” mill, having two smaller circulars rotating in the same direction, one cutting from the top, the other from the bottom of the log, in the same plane—one slightly in advance of the other (see Figs. 43 and 44).

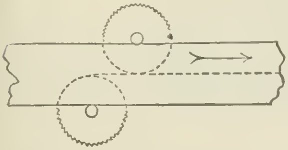

Fig. 43. “Double” Circular Saws.

Thus the 20-inch log cited above could be worked by two 30-inch circulars $\frac{9}{64}$ inch thick, and cutting only $\frac{13}{64}$ inch kerf. In general, the top saw is smaller than the bottom one, the lower one, after successive reductions of diameter by sharpening, being moved to the top mandrel.

In California, redwood logs ten feet in diameter are sawed with three 62-inch vertical circulars, one above the other, in connection with a small horizontal circular which divides the board in the line of the arbor of the middle saw. The two lower ones cut 58 inches between them, and the upper one takes 29 inches.

In the choice of velocity and teeth of circular saws, there must be taken into consideration the hardness and grain of the material to be cut; its greater or less freedom from moisture, from gummy or resinous matters, and from spikes; also its size and the degree of smoothness required in the surfaces left. The harder the wood the smaller and more upright should be the teeth, and the less their velocity and the rate of sawing.

Fig. 45 shows the circular saw solid tooth for soft wood; Fig. 46 that for hard wood.

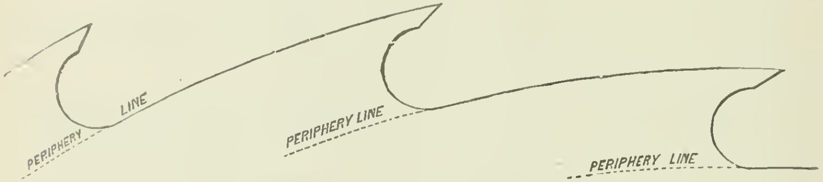

Fig. 45. For Soft Wood.

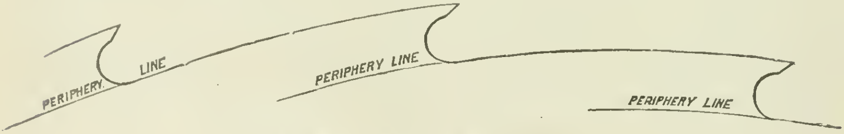

Fig. 46. For Hard Wood.

In cutting lengthwise with the fibres (slitting, ripping), the teeth should be coarse and inclined, and the speed moderate, so as to cut rather than abrade; as fine sawdust takes more power to make it than coarse.

Cutting across grain (cross-cutting, crossing) requires finer and more upright teeth and greater velocity than in the last case, so that each fibre may be rather *cut* by successive teeth than *torn* by only one.

The teeth should be as hooking as they will bear, except for lath saws, where the stuff is fed by the saw under the arbor, and for side cutting shingle saws, where this would cause too fast speed.

The more inclined a circular saw tooth is the easier it cuts. With less rake, however, the cut is smoother.

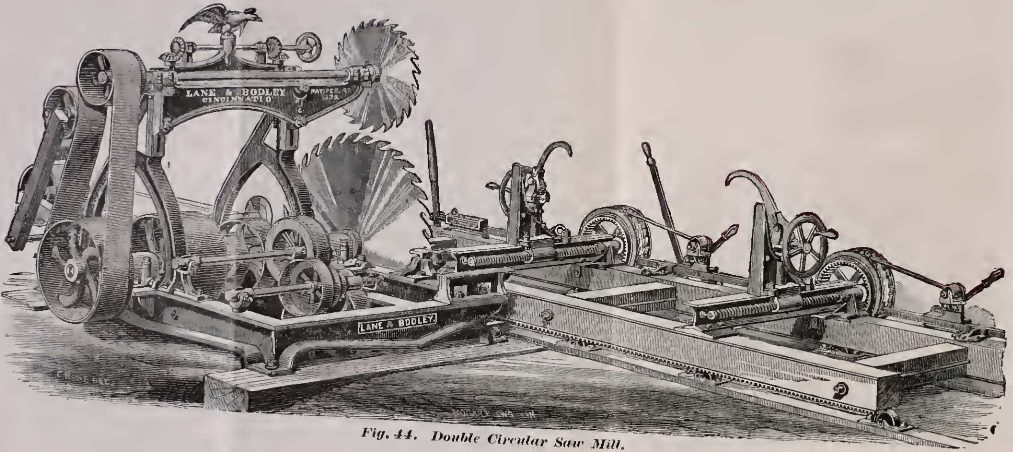

Fig. 44. Double Circular Saw Mill.

The teeth of the "circular" meet the fibres at varying angles. The fibres at the top of the "cant" are met at a very acute angle; those at the bottom at almost a right angle. (Fig. 47.) It follows that the first are cut to the best advantage, and that narrow cuts—that is, those of medium height of cut—are sawed less economically than thick ones, the position of the table being the same.

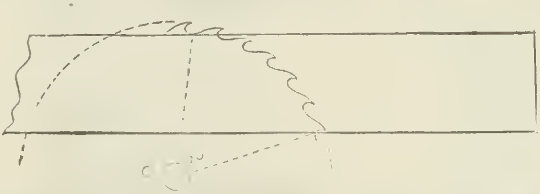

Fig. 47. Action of Top and Bottom Teeth of Circular Saws Compared.

Theoretically speaking, to effect the greatest economy in cutting, the table or carriage should be kept high up, so that the cant should be as nearly as possible tangential to the disk.

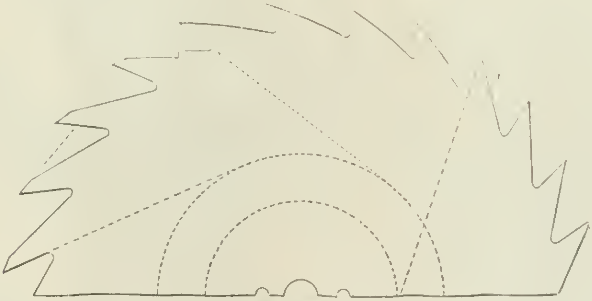

Fig. 48.

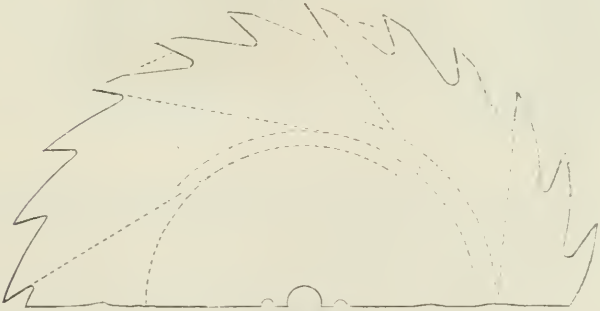

Fig. 49.

Figs. 48, 49 and 50 show teeth made to various tangents.

For pine, spruce and hemlock the teeth should be cut to a tangent to a circle half the saw diameter.

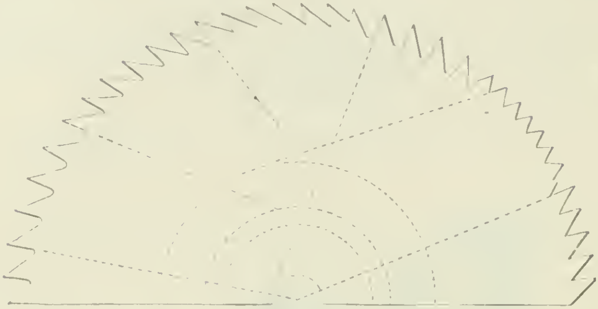

Fig. 50.

The old "Barber" patent tooth had the under side concaved out, and cut very sweetly. The Emerson inserted tooth of the present day has this same feature.

The Knowles tooth for circulars had its back slightly relieved—which really amounted to having the point slightly upturned.

The Gridley tooth for circular saws, shown in Fig. 51, as in order for work, has both spring and spread set. By use it becomes worn and rounded, as in Fig. 52. For light power and tough sawing it is said to do well. Its cutting point must be kept up square and full, as when rounded and dull (Fig. 52) it takes more power and turns out poorer lumber. It should be filed almost exclusively on the under side (as should any other tooth).

An arrangement of circular saw teeth, which is a development of the increment tooth referred to under the head of teeth, has sections of the periphery arranged with increasing spaced teeth—the inventor claiming smoother cutting with less consumption of power. He states that at Cincinnati a 7 gauge, 56-inch, variable spaced circular used from 7 to 20 horse-power less than any other of the same thickness. (See Fig. 53.)

The points *only* of circular saw teeth should touch the lumber. They should be *kept* sharp by constant filing, and set by springing and swaging, so as to clear the blades.

The American tendency is towards extra thin saws, as lumber becomes more and more valuable. They are now made to 54 inches diameter, as thin as No. 12 gauge at rim and 11 at centre; 66 to 72 inches diameter, No. 10 at rim and 9 at centre. In extra thin saws it is necessary to use a larger number of teeth than in thicker ones. Every $\frac{1}{16}$ inch saved in the width of saw kerf saves 1000 feet of lumber in every 16 M sawed.

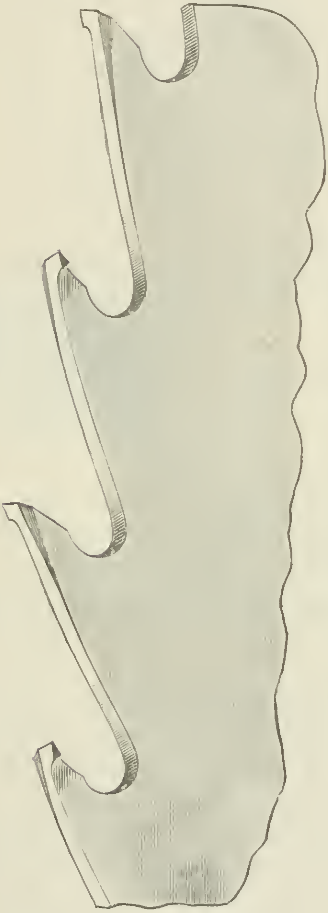

Fig. 51. Gridley Tooth, in good order.

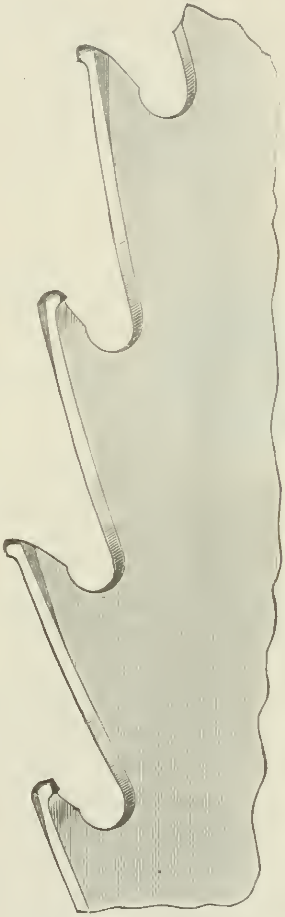

Fig. 52. Gridley Tooth, in bad order.

A circular saw has a great amount of difficult work to do, rapidly. It is something more than a hard steel disk. It must keep its position and work well when in rapid rotation and doing hard duty.

There is little real difficulty in making a "circular" with almost any kind of tooth, that will run well when new; but the steady use and constant changing of the teeth for months are sure to point out all their defects.

Hard circular plates heat easier than soft, and dry lumber causes greater heating than wet.

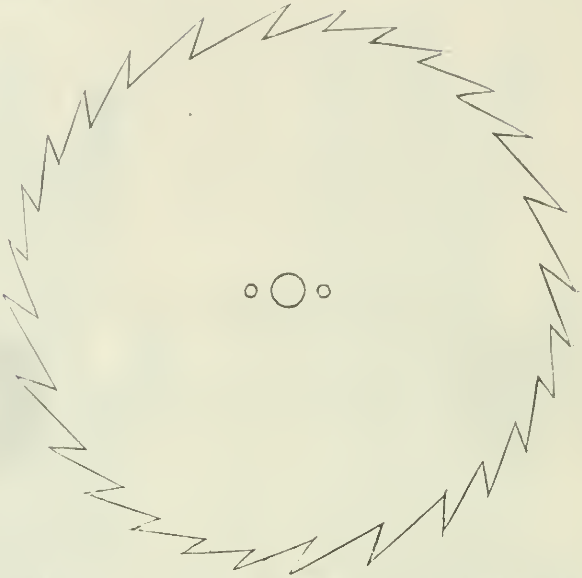

Fig. 53. Andrews' Increment Toothed Circular.

A taper circular will stand a higher speed than an even gauge or one ground thinnest in the centre, as there is less weight at the rim and consequently less centrifugal force.

As a slight offset to the advantage that rim tapering gives a circular, there is this: that as the saw gets smaller it gets proportionately thicker, when it does not need as great a thickness to keep it stiff.

Veneer-cutting circular saws are employed for making veneers or very thin plates, generally of valuable woods.* They are designedly thinner at the edge than in the centre, as the sheet removed readily bends aside. They are either solid or segmented. The edge must run exceedingly true, and the teeth be sharp and very faintly set. The segments are from 5 to 10 gauge, and are 12 inches in diameter.

A segment for large saws is shown in Fig. 54, and a veneer sawing machine in Fig. 55.

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* Knife or splitting machines for this purpose answer well enough for straight grained and pliant woods, as Honduras mahogany, but not for irregular, harsh and brittle grain, such as rosewood—as in the last case the veneer curls up considerably on removal, and has a disposition to split and become pervious to glue.

While circular saws for wood can be made up to 80 and 100 inches diameter, there are also smaller "circulars" used for such work as cutting notches in telescopes and in screw heads, slits of bat's-wing gas burners, etc. The teeth of these last are sometimes serrated with a screw cutter or tap, as in making the teeth of a worm-wheel. Perhaps the finest circular saws made are those for slitting the nibs of gold pens. The exact size of one is shown in Fig. 56. It is $\frac{1}{200}$ inch thick, and makes 4000 revolutions per minute. The cut is engraved by using as a transfer the saw itself, kindly loaned by Mr. Eberhard Faber, of New York. * * * * *

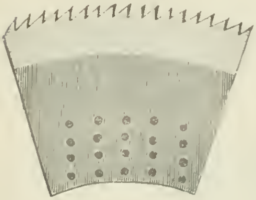

Fig. 54. Cutting Segment of Circular Saw.

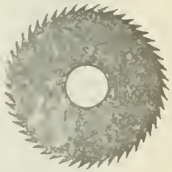

Fig. 56. Saw for Gold Pen Slits.

For sawing *loaf sugar* circular saw teeth are V-shaped, one-half inch apart, gauge No. 10, with great set. A 36-inch sugar saw runs only about 300 revolutions and under.

For *ivory* the teeth are V-shaped, 12 points to the inch, with no set. These circulars are 2 to 10 inches diameter, and of from 19 to 22 gauge.

For *bone* a $9\frac{1}{2}$-inch saw has 100 teeth, "handsaw" style in outline. The plate is 22 gauge, and an additional $\frac{1}{32}$ inch set is given.

For *iron* the handsaw tooth is used, with no set; space, 12 points; a 4-inch saw of 14 to 22 gauge runs 150 revolutions.

For cutting off wrought iron and steel beams Disstons recommend a circular 44 inches diameter and about $\frac{1}{4}$ inch thick, having peg teeth $\frac{3}{4}$ inch apart, with no set, and running slowly where neat cutting is required—say only 150 to 180 feet per minute peripheral speed.

Richardson Bros. say that circulars for wrought iron should have a speed of about 150 linear feet per minute; for cast or malleable iron, one-fourth faster, or say 190 feet per minute.

For *white or Britannia metal*, one-fifth the revolutions for wood (say 1800 feet per minute), but a larger tooth than for iron.

For *brass*, as fast again as for iron—say 300 to 375 feet per minute.

As regards the question of few or many teeth for wood cutting,

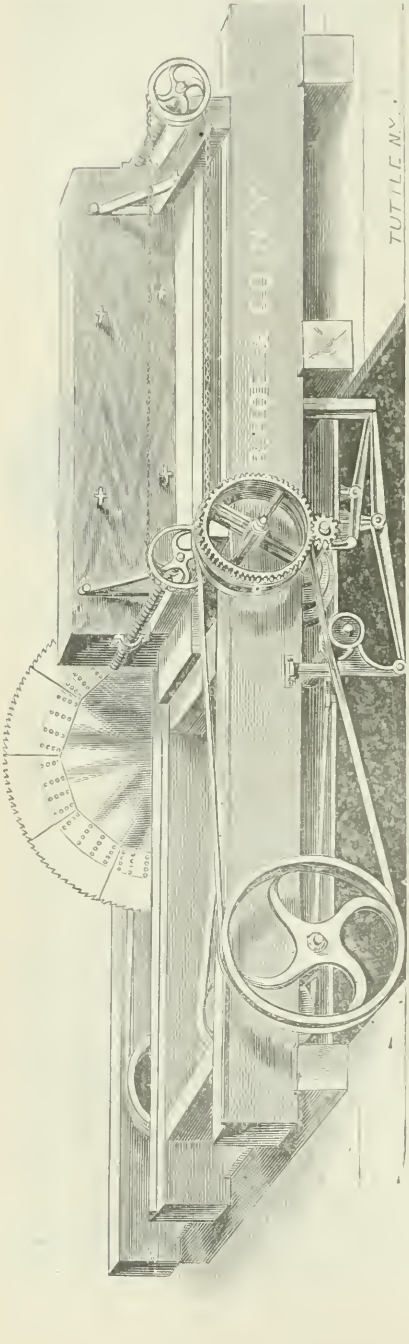

Fig. 55. Veneer Sawing Machine.

opinions differ, and yet perhaps without cause. The writer inclines to the belief that while the fewer the teeth the higher the feed capable per tooth, and the more chisel-like the action of the teeth, — yet there are cases where by reason of light power and hard cut more teeth are necessary. Certainly thin saws require the most teeth; or, to put it the other way, increasing the number of teeth enables the use of a thinner saw and less power.

Fineness of teeth also gives smoothness of lumber, as the teeth are stiffer and less likely to lead into the wood, and the saw marks are closer together than with many teeth.

In some parts of our Southern States where formerly a 56-inch circular had but 26 to 28 teeth, now there may be found a very large proportion of 56-inch disks with 56 teeth.

The fewest number of teeth we know of in a rotating saw is *two;* there being simply two long arms with a central hub, revolving on an arbor, and chiseling their way quietly and slowly through a log. This could hardly be termed a "circular saw," being rather a rotating chisel, and much like the Daniels planer used in car shops. * * * *

In times past the grinding process was so difficult and expensive that the flat "circular" was finished on the log side only. Nowadays many makers give the same accurate finish on both sides, and the saws can consequently be used either right or left "handed."

A variety of the circular saw is the *dished* circular, Fig. 57, used not for dividing material in a right line, but for cutting out beveled-edged disks, as barrel heads. Its action thus comes in between that of the circular and that of the cylinder saw. * * *

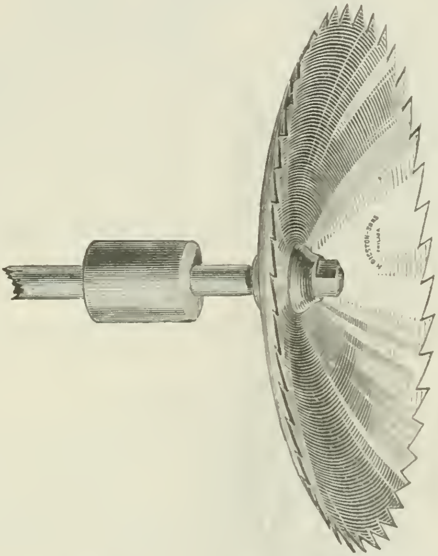

Fig. 57. Dished Circular.

Inserted-toothed circular saws, the use of which is already large and rapidly extending, have the following advantages over solid:

The teeth being drop-forged, from bar steel, are regular in size and shape, and of better material than is possible to use for the whole saw.

The teeth are capable of having more and better-shaped throat—a special advantage for coarse feeds, and for soft, wet and fibrous woods.

They cut so much smoother lumber that they are frequently spoken of as "planer-bits."

They effect a great saving in time and files and blades, over gumming and sharpening; they also avoid lessening the capacity of the saw by the reduction in diameter consequent on filing the solid saw.*

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*Cost of Running Planer-toothed Saws, as compared with Solid-toothed Saws.—Messrs. Emerson Smith & Co. give the following calculations:

The widely operating and successful use of emery wheels is, however, lessening this advantage.

The time of the mill lost while the solid tooth saw is being re-gulleted is important in new countries and in locations far from the saw factory—as New Zealand.

With a few thousand little "bits," costing three cents each, a New Zealand or far Canadian sawyer is independent of mishaps, even with the knottiest wood.

There is an avoidance of the necessity of readjusting and aligning the saw on the mandrel in the case where a spare saw enables the sawyer to save the otherwise inevitable stoppage of the mill in the case of a tooth breaking.

The spacing, set and shape of the inserted teeth is better than the

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"The average size of board circular saws is about 56 inches in diameter, so that we will base our calculations on that size.

"Circular saw mills vary in capacity from 5000 to 40,000 feet of lumber per day, 10,000 feet being about the average.

"Starting with a new 56-inch saw, at 10,000 feet per day, we will base our calculations on sawing 1,000,000 feet in 100 working days, or about four months

Cost of 56-inch solid saw, present price list	$117 00
One hour per day for filer, 100 days, 30 cents per hour	30 00

"In order to reduce the size of a 56- to a 54-inch saw, a strip of tempered steel, 14 feet in length, 1 inch in width, and the thickness of the saw, must be filed into fine dust. Besides, time is spent in spreading and setting the teeth and in rounding the saw.

1 dozen 14-inch mill files per month, at $9 per doz	$36 00
Gumming and straightening once in 2 months, say	15 00
Average cost of transporting to saw maker, say	6 00
Reduction in size of saw, say 2 inches, leaving the saw at the end of 4 months 54 inches in diameter, present price list, $96, reduction in value	21 00

"The above calculation estimates the reduction in the size of the saw at only one-fiftieth of an inch per day. If the saw is kept gummed down with a file, the cost of files and filing will be much greater than this estimate. If a gummer of any kind be used, add cost of the machine, wear of tools, wheels, etc., and the owner will find the cost more than the estimate of sending it to a saw maker.

Cost of mill standing idle, say half hour per day, in filing and putting saw in order so that the owner has lost the sawing of 500 feet of lumber per day, at $2 per 1000 cost of sawing for 100 days	$100 00
Total cost	$325 00
Cost of planer, saw and 1000 bits	200 00
Difference in favor of Planer Saw	$125 00

average sawyer would maintain even with the "guide lines" marked in the disk by some enterprising makers. (See Fig. 60.)

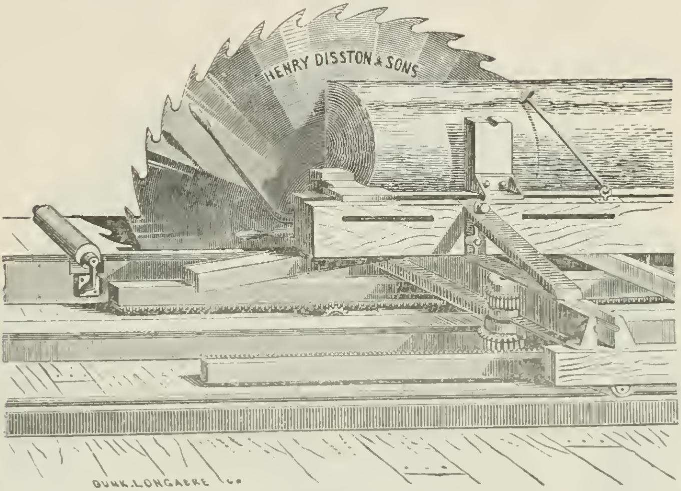

Fig. 58. "Right Handed."

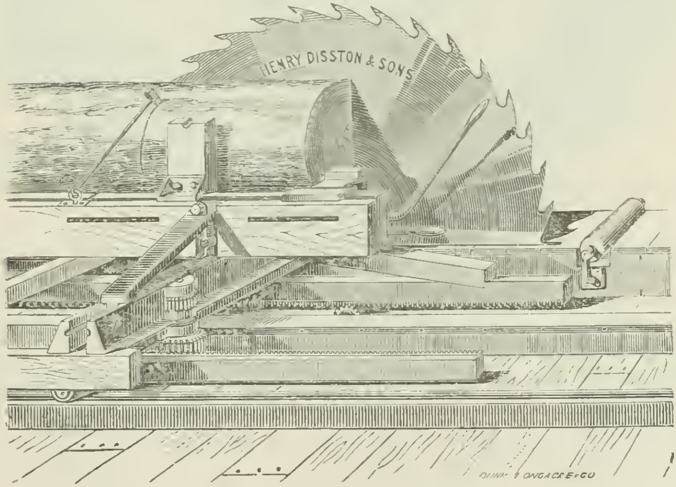

Fig. 59. "Left Handed."

Men capable of putting solid saws in order are very scarce. But in many mills are to be found men who are good, valuable sawyers, and understand turning out lumber to the best advantage, but who are poor filers. The inserted tooth makes their skill available.

The plate of a saw is nothing but a handle carrying the teeth, and is strained by the use of dull teeth. The inserted teeth can be kept sharp and hence strain the plate less.

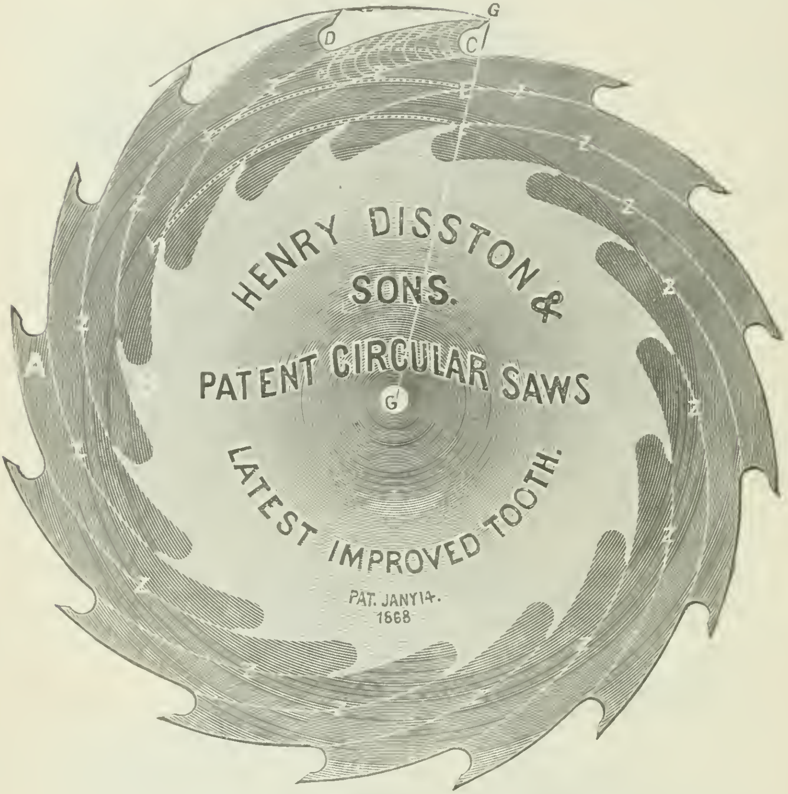

Fig. 60. Showing Guide Lines.

The cutting points or saw bits being shaped and sharpened while out of the saw, can, if it be the sawyer's fancy, be made slightly concaved on the under side, thus presenting full prominent corners a little in advance of the cutting centre; and in consequence of the corners of all teeth wearing faster than the centres the separate teeth will do more work with one dressing, than solid teeth, which are filed or dressed square. Fig. 61 shows their first state and mode of wear. They represent a top view of the points of teeth in various shapes. If the point of a tooth gets into the shape of Λ or any other irregular shape, it should first be squared and filed up into a regular shape, so that there will be an equal amount of metal on each corner. If a tooth loses a corner like that of B, the opposite corner should be filed off so as to have the appearance of C; swage it into shape like D, then bring it into a proper shape like E. A is also a bad tooth, having too much metal in one corner, and must be filed into the shape of C before it will spread properly.

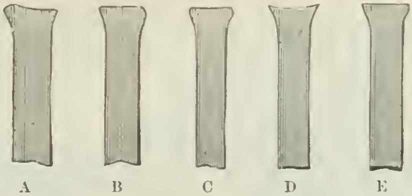

Fig. 61. Various Conditions of Teeth.

One file will go as far in keeping a good inserted tooth saw in order as ten with a solid saw.

An inserted-toothed saw can have hard or soft teeth at will, for varying kinds of lumber.

The Emerson bits are tempered to scratch glass, and weigh one-sixth ounce each.

The various items of power-saving by reason of keenness of cut and narrowness of kerf, are the same as are fully laid down on another page.

Inserted saw teeth came into use about 1840, the teeth being placed in rectangular sockets and held in place by a V tongue and groove. The rectangular sockets have been largely discarded for curved, as giving less liability to crack.

The following figures from the Albion Mill on our West Coast. show the performance of the Hoe chisel bit saw:

	No. days.	Feet Board Measure.
November,	26,	859,407
December,	23,	798,274
January,	26,	866,992
February,	25,	852,818
March,	25,	962,537
April,	26,	934,337
May,	10,	387,019
	162,	5,661,385

Number of bits used in the work, 1000 in all.

The bits are run in the Albion Mill as follows: Starting in the morning, with new teeth, on 4-inch feed, in hard pine or red-wood until noon. Then a set of new teeth run until night. At night the watchman puts in the next set. The dulled teeth are sharpened twice for the bottom saw and are then worked in the top saw. * *

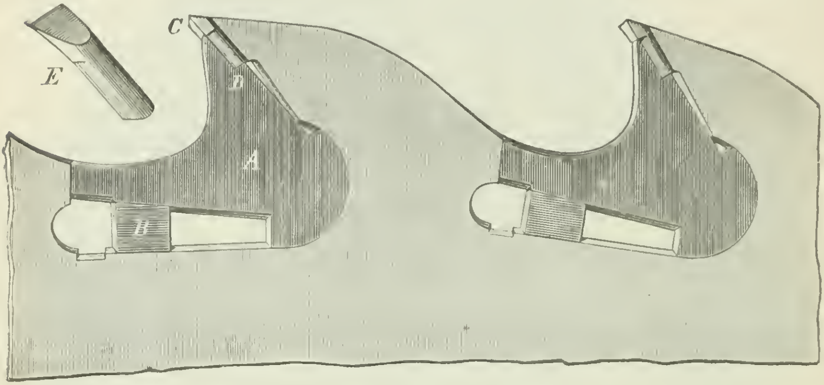

Fig. 62. Emerson's "Planer Bit."

Inserted toothed saws are made from 13 to 6 gauge, and from 12 to 72 inches in diameter, the smaller sizes being used for edgers and gangs.

Distribution of Atmospheric Pressure.—L. T. de Bort calls attention to the fact that in two columns of air, which have the same pressure at the surface of the ground, if the temperatures are different the decrease of pressure at higher levels is slower in the warmer column. Hence results a tendency of the air to pass from the warmer to the colder column, accompanied by a falling barometer in the former and a rising barometer in the latter. The effects of difference of temperature being generally opposite to those of barometer pressure, the transfer of air may be effected in the upper atmosphere, even when the pressure is lower at the bottom of the column. The ocean currents, in winter, augment, the energy of the atmospheric disturbances by increasing the opposition which already exists between the continental and oceanic temperatures.—*Comptes Rendus.* C.

ENGRAVING.

A Lecture delivered before the Franklin Institute, March 8th, 1880.

By JOHN SARTAIN.

The art of engraving on metal is unquestionably of very ancient origin, and must have followed closely on the discovery of the art of working metals themselves into articles of use.

The desire observable in all men, including the most barbarous races, to adorn their implements and costumes with ornamentation of one kind or other, whether color stains, carving, or incised lines, proves that a love of art is universally innate in human nature. Almost as soon as man had learned to make out of iron, or other metal, a sword, he would seek to embellish its handle, at least, with ornament in the nature of chasing or engraving. Thus must the art of engraving have become a familiar every-day affair even in pre-historic times. In the book of Genesis two men are named (Bezaleel and Aholiab) as being "filled with wisdom to work all manner of work with the graver," and in the other writing attributed to Moses we read these words, "Take now plates of gold, and engrave thereon, as in the engraving of a signet, 'Holiness to the Lord.'" This form of expression indicates a practice quite well known at that time.

But the art of engraving on metal plates for the express purpose of printing from them with ink on paper is quite a different matter, and is of a comparatively recent date. In the year 1452, a goldsmith of Florence, Italy, named Tomasso Finiguerra, made an impression on paper from a silver pax he had engraved for the Church of San Giovanni, of that city, the subject being "The Crowning of the Virgin." This pax still remains among the valued treasures of that Church of St. John, and the precious print from it is carefully preserved in the French National Library at Paris, where it was discovered by Zani in November, 1797. The pax itself was ordered from Finiguerra by the Consuls of the "Company di Calimala" in 1451, and the proof (a fac simile of which you see before you on the screen) was printed from the finished work before the artist introduced the niello into the engraved lines, as was the practice of the goldsmiths of Italy of that period. All this is authentic, and establishes beyond controversy that to this Florentine artist belongs the honor of having originated the art of plate printing.

In addition to the fac simile of the *undoubted* print by Finiguerra, I ask your attention to fac similes of two other prints that have been attributed to him: one, a Madonna, with the infant Saviour on her lap, and surrounded by numerous figures; the other is the circular print of the Gray collection (now in the Art Museum of Boston), and which has the arms of the Medici family sketched with the pen in the middle space. In the absence of all other evidence than that of style, I should say that it is the work of Baccio Baldini, after a drawing by Sandro Botticelli. If this print belongs to the early period ascribed to it, the Medici shield must have been inserted long afterwards, because the arms of that family used to have but five pellets, while the drawing on the print has six, as you see. The change from five to six occurred as late as 1533, when Catharine di Medici was married to the Dauphin of France., one of the stipulations of that arrangement being that a sixth pill, decorated with the French fleur-de-lis, should be added. The Medici, you know, were noted money lenders, and our modern pawnbrokers hang out *their* sign, but with the number abbreviated to three and those gilded. This fac simile of the Boston print was engraved about seventy years ago, by my father-in-law, Mr. John Swaine.

It was the custom of these artistic goldsmiths to fill in the lines of their engraving on silver with a semi-metallic substance called niello, which is a compound of copper, lead, oxidized silver, sulphur and borax. These were melted and thoroughly mixed together, and after cooling were crushed in a mortar into a fine powder. The plate was cleaned in a way that Benvenuto Cellini describes, and the powder spread over it. Heat was then applied from below, when the niello would melt and flow down into the lines at a temperature much lower than that which would affect silver. When cold it was ground down to the level of the silver surface, and the work was complete.

Before putting in the niello, Finiguerra was in the habit of filling the lines of his engraved plate with black and grease, and making an impression by pouring on to it melted sulphur. It afterwards occurred to him that this might be done on paper, by the aid of a roller, if sufficient pressure could be brought to bear upon it; he tried it and succeeded, but was for many years far from appreciating the value and importance of his discovery. It was not until about the year 1460 that plates began to be engraved for the express purpose of being printed from.

Engraving on wood was practiced in China many centuries before it was known or used in Europe, and whether Italy or Germany has the best claim to the honor of the invention, or of the earliest productions in this line of art remains an unsettled question, the preponderance of evidence being rather in favor of Germany. It is true there is record of a series of nine wood-cuts that have disappeared and have been sought for, thus far, without success. They are described by one who saw them in the year 1720 as representing eight scenes in the life of Alexander of Macedon and a frontispiece, in which last is a dedication to Pope Honorius IV. They were designed and engraved by the two Cunio, twin brother and sister, when but sixteen years old, and who lived at Ravenna in 1284–5 while executing these works. These prints may not have passed altogether out of existence, and may yet be found some day—possibly in the great Vatican library, since, having been inscribed to the artist's relative, the Pope, a copy was, without doubt, presented to him. He who has the good fortune to happen on these cuts will have as much reason to rejoice as did the Abbate Zani when he found the Finiguerra print in the library at Paris. Such a discovery would secure the claims of Italy to priority in *wood-block* printing, as well as that already conceded of *plate* printing.

Thus we see that line engraving on metal was practiced long before it was imagined that it was capable of being used to print from, but, on the other hand, we see that engraving on wood was originally devised for the express purpose of being printed from. The origin or first use of the latter in Europe is veiled in obscurity, and even if the Cunio prints should be met with, it would still remain uncertain how much had been done prior to their date. Pope Honorius IV, to whom those cuts were dedicated, governed the church but two years, from the second of April, 1285, to the third of the same month, 1287, an epoch anterior to all books printed in Europe that have hitherto been found. But, before books were printed, engraved blocks of wood were used for printing playing cards and other matters, and this may have suggested the idea of engraving entire pages of words on single blocks, which, in turn, gave place to the further improvement of movable types.

That wood engraving was already extensively practiced in Venice before the year, or at least as early as the year 1400, is evident from the following decree of the Venetian government in 1441, at which time the art is described as having fallen into almost total decay, owing to the too abundant importation of foreign productions in this line.

"MCCCCXLI. October the 11th. Whereas, the art and mystery of making cards and printed figures, which is used at Venice, has fallen to total decay; and this in consequence of the great quantity of playing cards, and colored figures printed, which are made *out* of Venice; to which evil it is necessary to apply some remedy; in order that the said artists, who are a great many in family, may find encouragement, rather than foreigners. Let it be ordered and established, according to that which the said masters have supplicated, that from this time in future, no work of the said art, that is printed or painted on cloth, or on paper, that is to say altar pieces (or images) and playing cards, and whatever other work of the said art is done with a brush and printed, shall be allowed to be brought or imported into this city, under pain of forfeiting the works so imported, and xxx livres and xii soldi; of which fine, one-third shall go to the state, one-third to the Signori Giustizieri Vecchi, to whom the affair is commited, and one-third to the accuser. With this condition, however, that the artists, who make the said works in this city, may not expose the said to sale in any other place but their own shops, under the pain aforesaid, except on the day of Wednesday at San Paolo, and on Saturday on San Marco, under the pain aforesaid."

Then follows the subscription of the Proveditori del Commune, and that of the Signori Giustizieri Vecchi.

The effect produced by this law of protection was all that had been expected. The art revived, and afterwards flourished to the extent, that, in addition to supplying the home demand for prints of the kind described, they commenced pirating the works of their neighbors, underselling the foreigner as the foreigner had before undersold them. Albert Durer suffered so much in this way that he made the *then* tedious and hazardous journey across the Alps from Nuremberg to Venice, to obtain redress from the authorities if possible.

I will now endeavor to describe the several processes of engraving in the order of their invention. They are seven in number. Engraving on wood, line engraving on metal (which includes etching) mezzotinto, aquatinta, soft-ground etching, chalk or stipple, and lithography. All these are wrought by skill of hand of the artist, and stand apart from those productions of the actinic property of light on sensitized films, made by the aid of the camera. These heliographic works are very beautiful, but are outside the province of this discourse, which is devoted to hand work only.

In wood engraving an artist first makes a drawing on a block of well-seasoned box wood, cut crosswise of the grain, and of about seven-eighths of an inch in thickness, corresponding to the depth of printer's type, because the engraved cut is frequently inserted among the set-up types to be printed along with it. The smoothed side of the block is prepared for drawing on by rubbing into the grain the white facing composition on enamelled cards, moistened, or with flake-white. At one time it was the custom to impart a tooth to the surface, for the freer delivery of the lead pencil stroke, by using bath brick finely powdered and moistened with water, and, when dry, smooth with the palm of the hand. The engraver then cuts away the wood between the lines of the drawing, leaving the wood standing on which the lines are drawn, and which are to receive the ink from the printer's roller, for the process of printing from a wood-cut is the same as from type, and by means of the same character of press. It is a surface printing and the ink used has to be of a consistency, and only in such quantity, as to deliver where it touches and not flow down into the engraved lines and dots, but rest only on the face of the lines and points left standing. This is exactly the reverse of the process of printing from an engraved copperplate, in which the incised or sunk lines are what must be filled with ink, and can only be made to deliver to the paper by means of a very severe pressure of the roller press.

The instruments used are gravers, tint tools, scoopers or gouges, and chisels or flat tools. The graver is used in the manner of a plough, and being driven forward ploughs out a furrow, delivering the material removed freely up the face of the graver. To economize time flat tools are employed in the wide open spaces. I abstain from the affectation of using the French word *burin* because the plain English word graver is better and more expressive.

Sometimes it may happen, through accident or error, that it becomes necessary to work over again some part. The remedy then is to introduce a fresh piece of wood into the defective place. A circular hole is drilled nearly through the block, of a size sufficient to cover that which has to be obliterated, and a nicely fitting plug inserted. It is then levelled exactly and the part re-engraved.

Chiaro oscuro drawings on tinted paper, having the high lights touched in with white chalk, are easily imitated in wood engraving by using a second block with the high light cut out. Suppose this tint block printed first with ink of a grey color and the picture-cut afterwards printed over it with black, an appearance will be produced of a drawing done on grey paper with the high lights touched in with white.

There is in Vienna an art publishing club a good deal interested just now in attempts to revive this practice of chiaro scuro engraving on wood, by which in old times very effective work was done by the use of two or three blocks. Mr. Baxter, of London, produced beautiful prints in oil colors by printing the successive tints from different engraved blocks. These effects have since then been rendered by the art of chromo-lithography.

Quite a revolution in the art of wood engraving has occurred in this country in the last few years, and is the result of the use of photography for placing on the block the drawing to be engraved.

By the introduction of this method copies of large drawings and boldly executed sketches are transferred to the surface of the block previously sensitized for the purpose—with a minutenss of detail altogether beyond the power of an artist's hand to draw. This naturally necessitated a corresponding minuteness of execution with the graver, at the same time, however, leaving little room for the display of the engraver's skill in freedom of flowing lines. In the old style the direction given to the line aided in expressing foreshortenings and the perspective of rounded forms, and our admiration was frequently excited by examples of masterly graver cutting. In the new school we have what may be by many considered better, the manner of the original artist copied is *more* prominent, the manner of the engraver *less* so. About the best work done anywhere at this time is that produced in New York, and this is not disputed even in Europe. The famous engraver, Thomas Bewick, of Newcastle, England, to whose labors is due the revival of the art toward the end of the last century, would not have believed it possible to engrave and print such cuts as are now published monthly in the city of New York.*

Line engraving on metal plates for the purpose of printing dates back to 1460, as we have already seen, eight years after the print was taken by Finiguerra from his Pax of the Crowning of the Virgin, although that print is believed to be far from the first of his printing, which some writers place as far back as 1440, only that Pax has a certain known date, 1452. Among the engravers who preceded Marc Antonio Raimondi the most prominent were Sandro Botticelli, Baccio Baldini and Andrea Mantegna, but these were not equal to Marc Antonio, whose works eclipsed all that had been done before in that line. He engraved a great many plates from the pictures and designs of Raffaelle, and that great artist took great interest in the work and corrected the outlines on some of the plates with his own hand. A fine example of this engraver's best work may be seen in the print of Poesy after Raffaelle, seen on the screen. This is not the original, but a very accurate fac-simile copy.

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* Numerous original examples were exhibited and referred to in illustration of the history and progress of the art, from Albert Durer, Burgmaier and others, down to the manner of later times.

The mode of procedure at this stage of the art was extremely simple, and called into requisition only four tools, a graver, scraper, burnisher and steel point.* The clean, polished surface of the copper plate is covered with a thin film of white or bees' wax, spread while the plate is just warm enough to melt it. When the plate has cooled, the outline drawing or tracing is transferred to this slightly adhesive surface by pressure. This process reverses the subject, which is an advantage, for all engraving intended for printing must be the reverse of the way it is intended to be in the print. The forms are then faintly scratched through the wax with the steel point. Then the plate is warmed and the wax wiped off. All the outlines and shades are then cut into the plate with the graver, and the rough barb or burr that hangs to the edge of the plowed line is removed by means of the scraper. When a proof impression has been taken by the printer, it may, perhaps, be seen that some lines have been cut deeper than is desirable, and others not deep enough. This is corrected by re-entering the faint lines and cutting them broader, and those that are too black are crushed a little with the burnisher. The plate is rubbed with oil and a roll of flannel, and is finished.

By this extremely simple process were engraved those superb examples of this kind of work done by the graver alone, without etching, which I direct your attention to on the screen. First, there is the print by Paul Pontius, the Fleming, after Vandyke, of the "Dead Christ and the Marys." In this style I cannot imagine anything finer. Correct in drawing and definition of form, faithful to the style and characteristics of the master, and with a confident freedom of graver line that is marvelous, and yet not obtrusive. And this masterpiece is wrought without the aid of the local tints and the charm of chiaro oscuro, but simply by the light and shade of the objects in the picture, for it was not then known that the engraver's art was capable of giving all the qualities that a picture possessed except its color.

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*These tools were exhibited and their use explained.

The next is a dashing piece of graver work by Bolswert, the Hollander, conveying an idea of Rubens' style remarkably well, although by such coarse means: and lastly, in this class of work with the graver, the group of Angels supporting the Tuscan Diadem over the arms of the Medici, after a fresco by Pietro di Cortona, in the ceiling of an apartment in the Pitti Palace, in Florence. I believe this to be by the French engraver Claude Mellan. It is almost all done with one line, without crossings, and is a brilliant example of that peculiar style.

I will now endeavor to explain the process called etching, the invention of which has been vaguely and erroneously attributed to Parmiggiano, who, besides being an admirable painter, was an alchemist, and wasted his substance and his health in trying to discover the philosopher's stone, in which unfortunate pursuit he is supposed to have fortunately happened on this method of engraving. But it is quite certain that the etchings by this artist were done long after Albert Durer had practiced the same art in Nuremberg, and, so far as we know at present, Germany must be credited with this admirable invention. In describing the process I will direct your attention to examples of the different kinds of work belonging to this group.

The foundation of the art is this, that acids corrode and eat into the metals, while resins and bitumens *resist* the action of acids. Therefore, if you cover the face of a copper or steel plate with a varnish of this nature you effectually protect the plate from the acid. If after having done this you scratch lines or dots through this protecting coating with a steel point, the acid gets access to the metal in those parts and corrodes it so deeply that, after the varnish has been removed by the aid of spirits of turpentine, these lines can be filled with printer's ink and will hold it the same as if they had been cut in with the graver, and a little better too. And this is etching. The varnish coating is called etching ground, and is compounded of asphaltum of Judea, Burgundy pitch and white wax, and is spread on the plate by means of heat.

The Burgundy pitch has the property of causing the compound to adhere tighter to the plate, and without the tempering wax the point would not cut so smooth a line through it. Your ball of etching ground is tied up in a piece of strong silk, the plate on which the ground is laid, having been made perfectly clean and free from grease. is held by a hand-vice and heated over a gas flame, or some other way, until it is hot enough to melt the etching ground, so that it comes through the silk on to the plate; then, with a soft dabber covered with fine silk or with kid leather, it is distributed evenly over the surface of the plate by dabbing, or on that part where your work is to cover. While it is still hot it must be held face downwards and smoked black by means of a flame from a torch made by several strands of wax taper. Without this blackening of the etching ground its semi-transparency would prevent you from seeing your work as you progress. The plate being cold you transfer your outline drawing or tracing by pressure, and proceed to make your etching with a steel point, just the same as you would make a pen and ink drawing on paper, but your hand must be kept from resting on the plate by a bridge, which may be made by a thin board resting on a book on each side of your plate: but engravers have a strip of wood fastened at each end of the etching bridge. Your etching done, it is bit in with aquafortis, a mixture of one part acid and about three parts water, nitrous acid being used for copper and nitric acid for steel. Hard steel bites better than soft. The work must now have a bank of walling wax built around it with a spout formed in one corner, and while moulding it into shape with the thumb and finger, take care to press it perfectly close down to the plate lest the acid should get under it. The bubbles that form on the lines during the biting must be swept away with a soft feather. In two or three minutes the aquafortis should be poured off into a wide-mouthed bottle and water instantly poured on, the work feathered as before to clear it from acid, the water poured off, and the plate dried with blotting paper or a soft rag tenderly pressed on it. The strength of the line can now be ascertained by scraping off a little etching ground on some light part. If found to be deep enough, paint over all the first grade of light tints with any kind of varnish that will harden quickly. English engravers use Brunswick black (I use red sealing wax dissolved in alcohol). This is called by engravers stopping out. Put on the same acid again, and bite the next darker grade of tints; operate as before and then bite in the third gradation, etc.

The gradation of tints need not be left *altogether* to the successive bitings, as by etching the dark parts of your plate with a stronger and broader point, and a firmer exercise of the hand, the biting of those parts is hastened.

The etching ground is now removed with spirits of turpentine and the work rubbed with oil and a woolen cloth, called the oil rubber, and then a proof taken by the printer. Where the lines are bit too dark bruise them down with a burnisher; where they are not dark enough you can either re-bite them or re-enter them with the graver. If you re-bite, dissolve some etching ground by heat applied under the plate—on the margin, if you have a broad one outside of your subject. If there is not an empty space on your etched plate large enough, you take a separate plate and, having heated it sufficiently to dissolve etching ground, you feed your dabber from this store, evenly spread, and deliver it over that part of your etching that is to be re-bit, which must be heated just enough to take the etching ground from the dabber on to itself. This is a most delicate operation and requires a steady hand, for the etching ground must be delivered only on to the *surface* of the plate between the lines and dots and none suffered to get into the work already bit. As this is not smoked you are able to see the strength of line you are obtaining while the biting is going on, and can stop it just when it is deep enough, according to your judgment.

Whatever addition you desire to your work of lines, more tender and delicate than the faintest of your etched lines, is produced with what is termed the dry point, that is, abstaining from the further use of acid, you scratch in with a point all the fainter tints of your picture and remove the burr only to just that extent that a printer's proof from your plate shows to be necessary. I will now point out the different styles of etching from the fine examples here displayed before you.

Some of these painters' etchings are what have been termed dry etchings, that is, they are, as you see, printed clean, without burr, and resemble a pen-and-ink drawing on paper. Such are those by Bergham, Salvator Rosa, Callot, Mortimer, Vandyke, Angelica Kauffmann, Ruysdal and others, and, contrasted with them, a class of etchings that depend much on skilful printing, having their darks massed and emphasized by blurring over the ink from the deeper lines so that no clear white paper shall appear between them. Of course the impressions from plates printed in this way are variable and uncertain, and some etchers escape being at the mercy of the printer by roughening the surface of the plate over the darks to make it hold the ink, and by spreading it obtain middle tint at the same time. Sometimes this tint is produced by corroding the plate, and sometimes by mechanical abrasion. It has been said of aquatinta engraving, that it was invented by the evil one expressly to torture those who practice it, and the same may be said of blurred etchings as an exquisite torture for plate printers.

During the past few years there has been gradually growing a passion for etching, and quite lately it has intensified into a perfect furor. Eminent artists, who know what they are aiming at in certain effects, are producing works in this way that the world will not let die; but, unfortunately, there are many who have not yet acquired a knowledge of the simplest principles of art, have also caught the infection and joined in the hot pursuit, and

> As their imagination bodies forth
> Things without form, they give their airy nothings
> A local habitation and a name.

I fear that I have dwelt so long on this branch of my subject as to exhaust the patience of of my audience; but I have desired to explain as fully as I could the *modus operandi* of etching and satisfy many inquirers at one time. The prevailing epidemic reminds one of some lines by Alexander Pope, which, by slight modification, are applicable to the present state of things.

> "Shut, shut the door, good John," fatigued, I said,
> "Say that I'm absent—say I'm ill—I'm dead!
> The dog-star rages, and 'tis passed a doubt
> A Bedlam full of etchers is let out;
> Fire in each eye, and etchings in each hand,
> They rave o'er proofs, and madden round the land."

Having now gone through with work done with the graver alone, and also with that done with acid and the point alone—each pure and simple—it is necessary to say something of the achievements—the triumphs of the engraver's art, produced by a combination of these two methods during the past two centuries, and I am happy to have it in my power to illustrate this branch of my subject by rare impressions of engravers' progress proofs of many important plates. I show you only a few now, as they will suffice for the purpose, and there is not room for more.

Alongside of these proofs of the etched state of the plate you see impressions of the same plates in the finished state, and they present through the eye a clearer statement of the method of procedure than I can convey in words. Take, now, this admirable plate by Robinson of "the Wolf and the Lamb," after Mulready, which, of its kind, may be regarded as a perfect work. The broad masses of dark, you perceive, are all laid in with the etching point and bit in, as are also such portions of the light as demanded the peculiar character of line which a graver cut cannot give. Such is the work on the broad mass of light on the fence in the foreground and the ground itself on which the figures stand, which latter is full of a character which could not possibly have been given with the graver. The lights of the drapery and all the flesh tints are left to be done with the graver, and by examining the two impressions together of each of the plates shown, you will come to understand the method of procedure in a general way. The etching and finished print of "Mercury and Argus," after Turner, and those of the "Temple of Jupiter at Egina," from the same painter, show this difference in treatment, that, being landscapes, there is a good deal of dry point work in the light tints, and as little graver work as possible. Where you see an etched tint fainter in the first than in the finished state, it has been darkened by rebiting; where it is too dark it has been reduced by crushing down with the burnisher, only, in the case of etched draperies, the darkening is done by re-entering with the graver rather than by rebiting. You will observe that where a dark drapery is etched, having a dark background also etched, the lines invariably stop short of the outline, leaving a white space like a chalk line. These lines are left to be carried forward to the boundary by the graver, because if done with the etching point they would all bite into a blot, since the curve they must take as they approach the edge brings them crowding nearer together; therefore they have to taper thinner and thinner, which can only be done with the graver.

But time presses, and I must rapidly close this branch of the subject without doing justice to it. One fine print you see, the "Massacre of the Innocents," after Le Brun, is only half a print really, and shows what has sometimes been done when a plate is inconveniently large. You see that the left side, as you view it, has a waving and not a straight boundary like the other side and top and bottom, because it is the middle of the subject, and has to be joined to the other half. The other half is in the Phillips collection, belonging to the Philadelphia Academy of the Fine Arts.

I think you may see before you now the perfection of work in line engraving and etching. The flesh tints in the plate of the "Princess Charlotte," after Lawrence, by Henry Golding, have certainly never been surpassed, and I doubt if they were ever equaled, I mean particularly the head, neck and bosom, and left arm and hand. This plate was four years on the engraver's table; he worked till he was eighty, and yet you will not find his name in any of the dictionaries of engravers, although you will find hundreds that are of little or no account. I cannot imagine it possible that Leslie's picture of "May-day in the Reign of Queen Elizabeth" could be better engraved than you here see it in the print by J. H. Watt; but who ever hears the name of Watt on the lips of those who talk about engraving? With regard to etching, Unger, of Vienna, is the prince of etchers, partly because of his unsurpassed execution, and partly because he gives the exact character of the painter he translates from. Look at that Ostade, that Ruysdael, Vanderwelde; and Rubens is so faithfully given in that triple print, that the very color is revived in the imagination. Then there is that triumph of the art in his copy of the gorgeous Makart "Catarina Cornaro receiving the Homage of Venice," the original of which was so lately lost to this country.

If Unger etched after Rembrandt, he would be even better than Rembrandt himself, whose extravagant coarseness in some parts of his plates it is only affectation to admire. If Rembrandt had possessed the use of mezzotinto for his peculiar effects, as John Martin had, what wonderful things he would have left us!

In the beautiful print before you, by Le Bas, after Teneirs, "the Distribution of Bread to the Poor," now in the Louvre, you see a remarkable union of the freedom of a painter's etching with the elaborate completion with the graver. It is a perfect copy of the painting, and it appears to me to be of the same dimensions.

Le Bas was French. The extreme opposite of his free style is that of Wille, who also flourished in Paris, but was of German birth. The print on the screen, copied from Schalken, is a fair specimen of Wille's style, which is mechanical and without feeling or artistic spirit; but his astonishing skill in the most exact and elaborate management of the graver in cutting pure silvery lines earned for him an immense reputation. His influence is of a kind that has caused it to be said, "It would be better for the art had he never been born." Bervic was his pupil, but free from the faults of his master, and he with Edelinck, Audran, Drevet, Nanteuil and their like, raised this branch of French art to a high degree of perfection, and it is well maintained in this later time by such men as Henriquel-Dupont, Forster, Jules Francois and others.

The admirable engraving by Robert Strange, after Benjamin West, entitled "Ah! si quá Fata aspira!" was completed in 1786, and for it he received the honor of knighthood. I will narrate a story in connection with this print, in as few words as I can; it displays a mean malignity on the part of King George the Third, of England, towards this engraver, that is astonishing. Those who visit the Museum in the Philadelphia State House will remember a whole-length portrait of that king in his youth; it was painted by Allan Ramsay, son of Allan Ramsay, the Scottish poet, and is one of a number of valuable pictures, the munificent gift to the Pennsylvania Academy of the Fine Arts by Mrs. Joseph Harrison, Jr. Ramsay was painter in ordinary to the king, and therefore was often called on to repeat his portrait for presentations, so this may be a duplicate, or it may be the identical painting I have to refer to. It is all the same. The king sent word to Strange, through Sir William Chambers, the architect, that he desired him to engrave this picture of himself and another, also by Ramsay, of Lord Bute (who was a crony of his), and he should be paid one hundred guineas on each plate, and all the profits from the sale. The engraver declined, and gave as a reason that it would interfere with a project he had of going to Italy to copy and engrave certain pictures in public galleries there. This angered the narrow-minded monarch, and he commenced a system of the most malignant persecution against the engraver, and continued it for near a quarter of a century. All connoisseurdom knew of the king's displeasure, and the subscriptions to Strange's prints suddenly ceased. In Italy his steps were dogged by a man named Dalton, who was the king's librarian, and as soon as it was ascertained what pictures Strange intended copying, his plans were frustrated by an application from the agent, in the name of the king, to parties without whose permission copies could not be made. I will read you one of the certificates afterwards obtained by the engraver.

"We Vincentius Malvetius, Cardinal Presbyter of the S. R. C., Archbishop of Bologna, and Prince of the S. R. Empire, To all and every one who shall see these presents, certify and attest; that M. Dalton, bookseller to the King of England, asked a permission from us, in the year 1763, to allow M. Bartolozzi to make a drawing for the said King of England. of the picture representing the Circumcision of our Lord Jesus Christ, painted by the celebrated John Francis Barbieri, Knight, commonly called Guercino da Cento; and we have granted M. Dalton's request, the permission was given accordingly.

"In testimony whereof we give these our letters, sealed with our usual seal, and signed by us at our Archbishop's Palace at Bologna, this 20th day of December, 1773.

"(Signed) Vinc. Card. Malvetius Archipiscopus.
"Paulus Canonicus Comes a Secretis."

It is needless to point out the mistake of the Italian in calling Dalton bookseller, instead of Librarian to the King.

This print by Bartolozzi, after Gureino, is in the splendid collection of Mr. Claghorn, and was once exhibited in the annex alongside of the Academy building. Having defeated Robert Strange abroad, the next thing was to head him off at home, and for this purpose inducements were held out to Bartolozzi to make England his home, which he did. Drawings by Strange were rejected at the Artists' Exhibition under the excuse that they were colored, although those by Bartolozzi, of the same character, were admitted. In the formation of the laws of the new Royal Academy, under the patronage of the King, engravers were excluded, in order to keep out Strange, although Bartolozzi was admitted, an operation which the king understood, no doubt, although he is said to have been puzzled to know how an apple could get inside the crust of a dumpling.

Finally, West, the peacemaker, suggested the engraving you see before you, which being shown at Windsor, the painter obtained leave to bring Robert Strange with him to the royal residence. A complete reconciliation resulted, and from that time forth the plates bore the inscription, "Engraved by *Sir* Robert Strange."

It is possible that the King's animosity may have been intensified by the fact that our engraver had been a Jacobite, and out with the Scottish army for the Pretender Stuart, in 1745, when his career very nearly came to a close. After the battle of Culloden, Strange was being pursued by some soldiers under the lead of an officer, and was seen to take refuge in a house that stood alone. The men were posted around to render escape impossible, while the officer entered suitably attended.

The lady of the house was seated in the parlor, and to her the gentleman apologized for his intrusion, but said it was his duty to arrest the man who had taken refuge there. She told him that she had no right to object, and accordingly the search was made, but nowhere could the fugitive be found. The disappearance was most extraordinary. The officer again apologized and bowed himself out. As soon as it was perfectly safe, Strange emerged from his place of concealment, which was under the lady's ample skirts. She afterwards became Mrs. Strange, and this you will say is not *strange*.

The third style of engraving in the order of my list is mezzotinto, and its invention dates back to 1640 at least, as there is a print in this manner, bearing date 1643, done by Ludwig von Siegen. He and Prince Rupert were acquainted, and to the latter the invention has been credited by some, but whether rightly or not will probably never be known.

The leading characteristic of the process is pretty well described in an anecdote of the camp, true or false. It is said that Prince Rupert, in strolling through the camp, observed a soldier grinding out the rust from some piece of armor. Part was done and part not begun. This suggested to the mind of the general the idea of roughening a plate all over so as to hold printers' ink, and then to remove this in parts forming the lights of a print.

The surface of the plate is covered with myriads of dots by means of a mezzotinto grounding tool or rocker. It is (as you see) like a broad chisel of steel, scored on one side with fine grooves, equidistant and of equal depth. Thus is formed on the edge a row of projecting teeth, the end being sharpened at a bevel and curved, so that it can be rocked from side to side, held slightly inclined with the teeth on the plate and advanced forward between parallel lines while rocking. At every new covering the direction has to be changed, so as to avoid, if possible, going over in the same direction twice. When the surface is completely covered and made black with dots the ground is complete, and if a printer took a proof from it it would yield a perfectly black impression. The picture is then made by scraping away these dots down to the very bottom, where the pure high lights are to be, scraping them partly away for the middle tint, and leaving them as left by the rocker for the extreme dark. Formerly mezzotinto was used pure and simple, without a foundation of deep etching as now, and it derives its name of "mezzotinto," half tint, from the softness of its effect. But at this day an etching is made, sometimes quite elaborate, before the mezzotint ground is laid, and it is intended that this should show through the mezzotint after the scraping is done. The mixed manner of line, stipple and mezzotinto is now the prevailing style in England, and has been for the past forty or fifty years, for framing prints. Line engraving continuing to be used for plates of smaller size, especially for book illustrations. Large line plates are seldom engraved, except for art unions, and there are instances of amateur clubs, composed of men of means, who subscribe money to enable an eminent engraver, like Mr. Doo, to devote himself to first-class work in this line.

I show you here a large plate by Samuel Cousins, after a picture by Sir Thomas Lawrence. It is a superb work, and is almost a pure mezzotinto; any one not blinded by prejudice must say that a more faithful translation of a painting could not be made. The drag and sweep of the painter's touch is imitated, as well as all the other qualities, except its color. The same engraver finished a mezzotinto plate last summer, of "the two Princes in the Tower" (from which the wood-cut I now show you was copied), and was paid more than eight thousand dollars for it. It was smaller than this plate of Pius VII. and there was not half as much work in it.

It will be conceded that there is no class so difficult to satisfy as the painters, and there certainly can be none better qualified to judge of what is most desirable in art. Now, the forty who constitute the Royal Academy at London had occasion, after the repeal of George III's vindictive regulation, to select one engraver as a representative of the entire profession—the whole art, irrespective of style—and the choice fell on the man of mezzotints, Samuel Cousens.

There is a confusion of terms among persons not over well-informed on art matters that needs correcting. For example, there are many, who, if asked what these line engravings are will promptly answer "those are steel engravings." Next ask them whether these mezzotints are also steel engravings, they will answer, "No, of course not; they are mezzotints; they're not steel." Now the fact is those mezzotints *are* steel engravings, and the others are not. Mezzotints are *always* done on steel, and line engravings are frequently done on copper. All that are seen here, except the mezzotints, are copper. There is no sense in the term "steel engraving." It expresses nothing of style, and the fact of a work being done on steel ought not to be a recommendation, for it makes it none the better, except to the publisher, who can get from it a larger number of impressions.

The printing of mezzotints, when done rightly, is different from line printing, and the two styles ought not to be carried on in the same printing office, because the material and the method used in line work is so much easier than the other that the men are sure to use both for mezzotints. This is what brings the style into discredit—bad printing—and publishers go so earnestly for the cheap that the prospect is hopeless. As Thomas Carlyle says, "cheap and nasty," and the latter is accepted for the sake of the former.

Plate printers' ink is made by grinding a fine kind of charcoal into linseed oil that has been burned and oxidized until it will draw into unctuous threads between thumb and finger. Lampblack, such as is used in woodcut printing, won't do at all. The best and only proper black is made from the skins and seeds of grapes after the juice is pressed out for wine. Manufacturers of Mayence and Frankfort buy up this material, burn it and grind it, and it is called Frankfort Black; and these Frankfort manufacturers supply all places in the world where good work is done. During the first Napoleon's war with England the commerce with the continent was cut off, and English plate printers could not obtain Frankfort Black. Then the Society of Arts offered a liberal premium to any who would produce a black having the quality of Frankfort Black and to be no dearer. They continued the offer for at least twenty years after the continent was open to their trade, but the want remained unsupplied. In good printing, with the proper black, the print should appear, on looking along it towards the light, like black velvet on white satin, the hot polished plate giving a satiny polish to the paper, while the ink stands up from it like black velvet.

Impressions from plates engraved in the style termed "aquatinta" resembles in appearance an India ink or Sepia drawing, according to the color of the printers' ink used in printing. The invention is attributed to a French artist named St. Non, and a little later than the introduction of mezzotint; it was successfully practiced by a German lady, Madame Catharine Prestel. It was introduced into England by Paul Sandby about the middle of the last century.

The etching ground in this method is resin, and in France is spread on the plate in a shower of fine powder, and then fixed as it falls by means of heat applied from beneath the plate. The English method is to dissolve the resin in alcohol and pour it on to the plate. When the alcohol has evaporated the resin is found in small granules all over the surface, with fine cracks between them, leaving the copper thus exposed so that when aquafortis is applied it will corrode the plate at these cracks and not where the grains of resin adhere. The guide lines of a tracing or outline drawing are transferred on to this resin ground, a banking wall of wax with a large spout at one corner is formed on the margin around the subject, and the high lights are touched in with stopping-out varnish, the same as in etching, already described. Every successive gradation of tint is produced by this stopping-out between each biting till the deepest tints are obtained. The plate is then cleaned with spirits of turpentine and with alcohol, the resin yielding only to the latter solvent.

After a proof has been taken it may be found that some of the darks are deficient in intensity. The remedy is to pour on a new ground after making the plate perfectly clean, and the resin will granulate over the previous formation and form a re-biting ground. You now prepare a paint of yeast, molasses and whiting, or of gamboge, sugar and whiting, and with a sable brush touch in where the deeper darks are needed. Foliage relieved against a sky lighter than itself should be treated in this same manner. When this composition is quite dry, cover the whole surface of the plate with stopping-out varnish and let it dry hard. If aquafortis were now applied it could have no effect, because the entire plate is protected. Next stand the plate on an inclined position, face outward, and pour warm water over it. Fermentation begins wherever the composition has touched, and forcibly bursts away the outer varnish, and the flow of water carries it off as fast as it is liberated. The aquafortis is then applied in the manner before described, the plate cleaned, and the work is done. If edges of some of the tints are found to be too harsh and abrupt they are corrected by the use of the burnisher.

It has been found that the liquid ground granulates into a better grain on copper than on steel, and that the addition of a little sal-ammoniac improves the biting quality of the aquafortis. Great care is necessary that not the least particle of dust falls on the resin ground while in a liquid state, as it ruins it and it must be cleaned off.

Stipple engraving, a style of work done with dots in place of lines, is the same in all its methods as that already described for modern line engraving, that begins in etching, except that the graver used is slightly curved with its point downwards, and the handle reversed so as to present the tool at a greater angle to the face of the plate. It was invented by Bylaert, of Leyden, but introduced into England from France by the unfortunate Ryland, he who executed the two whole length portraits that Robert Strange had refused. I say unfortunate, because he himself was afterward executed for the crime of forgery.

With the introduction of stippling began the publication of colored prints. The examples before you, after Stothard and Angelica Kaufman, are not colored with the brush on to the print, but are printed in oil colors from the plate itself at a single impression, the colored inks being worked into the dots of the hot plate, with the finger in the small spaces, and with the dabber in the broader ones. Among the most successful of the earlier stipple engravers was Bartolozzi (equally skillful in line, however), and you here see impressions of the etching and finished state of one of his plates in this style.

The stipple was sometimes used to imitate the strokes of a crayon drawing, as in the print before you, after a group in West's "Christ Rejected" (one of the pictures presented to the Academy by Mrs. Joseph Harrison). When in this form it was known by the term "chalk engraving." Since the discovery of crayon lithography chalk engraving has gone out of use, because the real thing is better and easier than the imitation.

Soft-ground etching has also been driven from the field by the introduction of lithography. It is the simplest and easiest of all the methods, and but few words will suffice to describe it. The example before you is by George Morland, and the fac simile of Raffaelle's study from nature for Adam in the "Temptation" is mainly by this method, but it had to be helped out afterwards with some dry point-scratching.

The ordinary etching ground has to be melted again and about one-third of its bulk of lard incorporated with it. From this it derives its name. In cold weather it requires more lard, and in warm weather less. It is spread over the plate and smoked in the same manner as hard etching ground, and then care must be observed that nothing touches it.

Take a sheet of writing paper, one inch larger every way than your plate, dampen it, and place it cautiously over your ground, turning the margin over the back of the plate, to which you fasten it with paste or otherwise; when dry, it will be stretched quite smooth. Take an H or HB pencil, and draw your subject on it just as you wish it to appear, pressing harder where your darks are to be, and lighter for the more delicate parts. According to the weather, or as your ground is softer or harder, you select the pencil, remembering that the softer the ground the softer should be the pencil. When the drawing is finished, lift the paper carefully from the plate, and wherever you have touched with the pencil the ground will have adhered to the paper, leaving the metal plate more or less exposed. A wall of wax is then put around the subject, and the biting with aquafortis proceeded with as in other etching. If all things have gone right, a proof from the plate should resemble exactly the pencil drawing on paper, by the soft etching ground sticking to the under side of the paper.

Engraving on stone (called lithography) is not done with a graver, but with a steel or a diamond point. A smoothly polished stone is covered with a thin coating of gum water and lampblack, and the lines are drawn through this with the point, broader points being used when lines are wanted broader, not by pressing deeper into the stone. Thus the etched lines show white in the surrounding blackness, just as an etcher on metal plates is enabled to see his work by means of the smoked etching ground. The work being done, the lines are filled with greasy ink, and when the printer has cleaned off the gum and black the work appears as black lines on the white stone. After having submitted the work to the process of fixing, it is ready to print. There is quite a variety of lithographic processes practiced, but they are outside the boundary of my subject, even if there were time to touch on them.

I must now conclude, regretting that there is not time in a single discourse to taker a broader survey of this interesting subject. I have crowded into it as much as I dared, and no doubt have fatigued you all.

Cheap Dyes.—Hugo Söderström calls attention to the importance of using cheaper dyes in place of some of the exotic products, such as the yellow wood of Cuba, fustic and quercitron. He mentions especially dyers' weed, saw-wort, broom, the wood of the mulberry and acacia trees, dried pear leaves, oak bark, the bark and young shoots of the poplar, sorrel roots, the leaves of the great nettle, and juniper berries, giving rules for their successful employment.—*Wollengewerbe.* C.

ON D'AURIA'S ENGINE GOVERNOR AND THE ACTION OF GOVERNORS IN GENERAL.

By the Inventor, L. D'Auria,

Professor of Applied Mechanics, former Engineer of the Military Topographic Institution in Italy, etc.

In March, 1879, the writer of this note submitted to the Committee on Science and Arts of the Franklin Institute of the State of Pennsylvania an improved engine governor of his own invention, called "D'Auria's Engine Governor," which was examined on model and drawing, and found to be "very simple and compact, cheap in construction, comparatively small in dimensions, extremely sensitive, quick in action, nearly frictionless and isochronous." It was constructed upon the theory set forth by the inventor in the Franklin Institute Journal of March, 1879. After this examination the committee expressed the desire to make a practical test of the governor, and a 1-inch D'Auria's Engine Governor, furnished by the inventor, was attached on the engine of the Franklin Institute.

This governor, except the case when the engine was run without load, was found to act practically in accordance with the previous views of the committee. It commanded three different speeds to the engine, by means of three different sets of pulleys, and these speeds were 78, 62, 48 revolutions per minute when the engine was employed in running the dynamo-electric machine, and 76, 62, 48 revolutions per minute when the engine was running said machine together with an additional resistance procured by a brake lever. When the engine was run without load, the leakage of steam through the governor valve (which was a kind of oscillating slide valve, adjusted rather loosely to prevent friction) caused the engine to run at a greater speed than that due to the sensitiveness of the governor. Considering the engine was run at a very low speed, this inconvenience was of little importance, and even this source of objection has been successfully eliminated by the inventor, by using a balanced poppet valve as a substitute for the balanced slide valve. This improvement is shown, together with some little change of form of the governor itself, in Fig. 1, in which the balanced poppet valve (shown apart in Fig. 2) is horizontally disposed within a valve chamber, *E*, made in the governor spindle, *K*, at the end of a cylindrical tube, *T*, which tube forms a practically tight steam joint with a steam box, *B*, provided with an induction passage, *I*.

The governor spindle, *K*, projects from the steam box, *B*, through a stuffing box, and receives rotary motion from the engine by means of gear, etc.

The steam box, *B*, is provided with a flange, and covers a larger steam chamber, *S*. An eduction passage, *D*, leads from the steam box to the engine, in which steam chamber the valve chamber, *E*, and its valve revolves.

The governor arm, which is formed by two equal side pieces, *AA*, riveted on each side of a ball, revolves also in the same steam chamber, *S*, being hung on both sides of the valve chamber, *E*.

The position of the point of suspension and that of the centre of gravity of the governor arm in reference to the axis of rotation, in order to obtain the closest approximation to isochronism, are determined after the theory set forth in the FRANKLIN INSTITUTE JOURNAL of March, 1879, page 130.

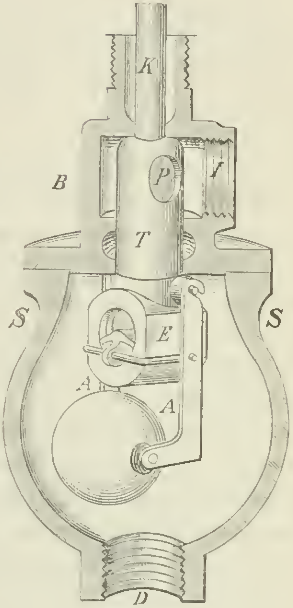


Fig 1.

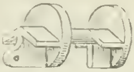


Fig. 2

The connection between the governor arm and the throttle valve is made by a wire bent in form of U, as shown on the drawing, the sides of which are confined between the sides of the governor arm and the walls of the valve chamber, so that it cannot come out unless the governor arm be taken apart from the valve chamber to allow the wire to spring.

When the governor arm swings upwards by the centrifugal force acquired through the act of revolution, the valve is carried towards its seats.

The valve moves on three wing guides, which are constructed so as to permit it to oscillate with extremely small resistance; moreover, the valve does not enter the seats, but rests only upon the edges, thus forming the limit of motion and controlling the range of the governor arm in swinging upwards. The contrary motion of both valve and governor arm is stopped by the contact between the cross bar of the connecting wire with the valve chamber.

The steam from the boiler enters the induction passage, *I*, and flows through the openings, *P*, of tube *T*, to reach the valve chamber, *E*, after which, if the ports of the latter are opened, it will be delivered in the steam chamber, *S*, from which it will flow to the engine through the eduction passage, *D*.

As the weight of the throttle valve is very small, as compared with that of the governor arm, the frictional resistance is easily overcome by the least increase or diminution of centrifugal force of the governor arm, produced by any small variation of speed of the engine; and the governor being isochronous, the effect of such small variations of speed will be to entirely shut or open the valve chamber of the governor, and therefore to compel the engine speed to oscillate between very close limits.

Such a governor will not only control the speed of an engine to a definite number of revolutions per minute, but it is also able to control the irregularity of a single revolution of an engine, when it must be observed that during the period of expansion of steam the action of the governor is ineffective. If at such period of the stroke an increase of load takes place, it must be controlled by the momentum either of a flywheel or of parts of machines which derive their motion from the engine; and if the speed passes, in either direction, the limits due to the sensitiveness of the governor and its control of the valve during the period of expansion of steam for each stroke, such effect can only be attributed to a deficiency of such momentum.

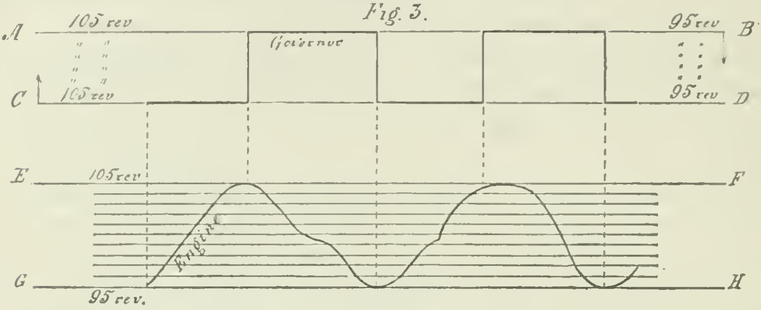
A great momentum in an engine is always beneficial to the action of the governor, its operation being to lengthen the time in which a change of speed takes place; but it does not in any way affect the sensitiveness of the governor. In other words, it may reduce the acceleration and retardation of speed, but it will not prevent the engine from reaching the extreme limit of its speed due to the sensitiveness of the governor.

It can be asserted that an isochronous governor, when practically frictionless, has a complete control of a steam engine. On the other hand, with a governor subjected to a considerable friction, a better control is obtained when the isochronous properties are avoided. These propositions can be demonstrated as follows:

Imagine two governors, both subjected to friction, one isochronous and the other non-isochronous. Suppose the first, if frictionless, to have its steam passage opened or shut indifferently, running always at 100 revolutions per minute; and the second, also, if frictionless, to have its steam passage full opened, running at 98 revolutions per minute; and quite shut, running at 102 revolutions per minute. Moreover, suppose both governors require 5 per cent. more speed to overcome their friction while the valve is moved in the direction to shut the steam passage, and 5 per cent. less speed while same valve is moved in the direction to open it. Suppose, further, that the engine is running with its steam passage full open, with a gradually accelerating velocity of rotation. As soon as the speed of the isochronous governor reaches 105 revolutions per minute the steam passage will be suddenly closed by the governor valve; the speed of the engine will be now retarded, with more or less rapidity of retardation as affected by the momentum of the flywheel or moving parts, until 100 revolutions per minute is reached. At this rate of speed the governor, by our supposition, does not offer to move the valve in the direction of opening, but the operation of retardation must progress, by absorption of force from the momentum of the moving parts, until the speed falls to 95 revolutions per minute, when the valve will be full opened by the governor with the same suddenness of action. With such a governor the engine speed will be established at velocities oscillating between 95 and 105 revolutions per minute. Then if a change of load brings the engine speed to one of these limits, the governor will undoubtedly change the speed to the other limit. A graphical representation of this is given in Fig. 3, in which the distance between *AB* and *CD* represents the stroke of the governor valve. *AB* corresponds to the position of the governor valve when it shuts the steam passage, and *CD* corresponds to the position of this valve when it opens the steam passage entirely. *EF* and *GH* represent the limits of the engine speed in revolutions per minute. Between *AB* and *CD* is the line representing the action of the governor valve, and between *EF* and *GH* is the line representing the speed of the engine, with variations which correspond graphically to the action of the governor valve.

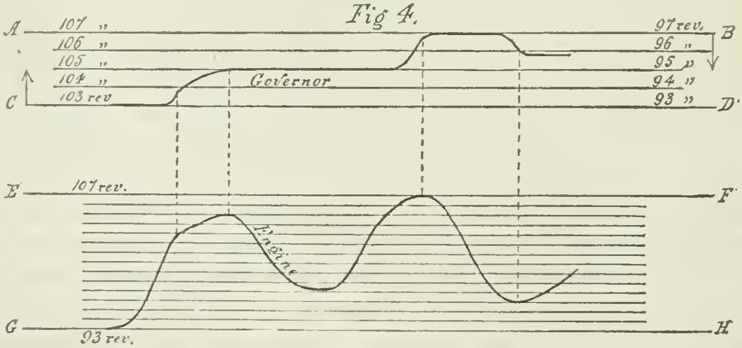
Between *A* and *C* are marked, in revolutions per minute, the positions of equilibrium of the governor while the valve moves to shut the steam passage, and between B and D are marked, in the same manner, the positions of equilibrium of the governor while the valve moves to open the steam passage.

Fig. 3.



Examining now the non-isochronous governor, with a similar supposition of open steam passage and with the speed accelerating above 102 revolutions per minute, the valve will begin to close the steam passage, and it will gradually be reduced by the valve while the speed passes from 102 to 107 revolutions per minute. When the latter speed is reached, the steam passage will be quite shut, and it will not begin to open until the speed falls to 97 revolutions per minute, because the valve would keep the steam passage closed with the governor, if frictionless, running at 102 revolutions per minute; therefore, to overcome the friction while the valve moves in the direction to open the valve chamber, according to our supposition, the speed must fall to 97 revolutions per minute. While the speed passes from 97 to 93 revolutions per minute the steam passage will be opened gradually.

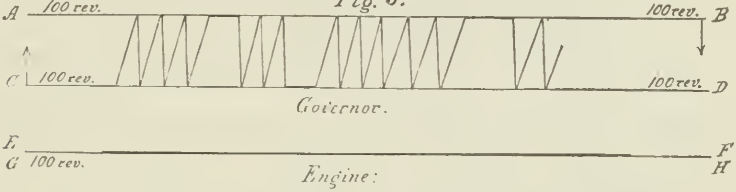
Fig 4.



With such a governor the engine speed *can* oscillate between 93 and

107 revolutions per minute; but if a change of load brings the engine speed to one of these limits, then the valve will gradually open or shut the passage of steam; and it may be asserted that before the passage shall be either opened or shut, the engine will have been regulated in speed, and the uniformity of speed may be maintained with a *partly* open steam passage until another change of load may disturb it. This makes a non-isochronous governor preferable to an isochronous one, when both are subjected to frictional resistance to be overcome by the governor itself.

Fig. 5.



A graphical representation of the action of the supposed non-isochronous governor at various rates of speeds for the engine is given in Fig. 4, with the same letters of reference as in Fig. 3, referring to the similar things.

A graphical representation of the action of an isochronous and frictionless governor, and that of the engine speed, is given in Fig. 5, also with the same letters of reference as in Fig. 3, referring to similar things. In this last representation the engine speed is shown by a straight line—a condition which follows, because an isochronous and frictionless governor commands an engine to run with uniform speed.

Supernumerary Rainbows.—When a rainbow is very brilliant, secondary or supplementary bows are often seen near the centre of the arch. Kaemtz, Langwith and other observers have supposed that the reduplication is never visible near the extremities of the bow. Montigny saw, in August last, two ordinary bows with four supernumerary arches near the ground, which extended to about a third the height of the inner bow. There were two distinct layers of rain-clouds, and the supplementary bows seemed to be formed in the lower layer.—*Bull. de l'Acad. de Belg.* C.

A NEW HYPOTHESIS REGARDING COMETS AND TEMPORARY STARS.

By Thomas William Tobin,
Professor of Physics, Central University, Richmond, Ky.

Every new achievement of mechanical science to aid vision in the investigation of the heavens has been eagerly directed to the constitution and movements of those bodies known as comets. Conformably with the universal laws of gravitation, their orbits have been observed to be curves of the conic sections. The conclusion, therefore, that being subject to these and other laws of matter, they are of a material nature, is generally believed by astronomers. In some respects, however, they appear as embodiments of force, or constituted of material of such an attenuated form as to have, as far as we know now, no terrestrial equivalent.

Those having parabolic and hyperbolic orbits are doubtless visitants from other systems than ours, returning in new paths to again encounter other systems. We may regard them as the true planets of the siderial heavens, so erratic must be their paths in space.

There is another class of siderial phenomena to which the merest hypotheses can be applied, and even then with but little satisfaction to the mind of the investigator. It has afforded a field for the wildest flights of imagination in darker ages of astronomy, and frail romance has interwoven it with immediate divine interposition. It is the sudden appearance and equally sudden disappearance of stars in the heavens.

Of this class we may take, as a notable and historical example, the temporary star of 1572, which was observed and recorded by the celebrated Tycho Brahe. "Suddenly," says the record, "there appeared in the constellation of Cassiopeia a star that in brightness surpassed Sirius, and it could be compared with Venus when she is at her brightest. It was seen in the day time, and at night through clouds of considerable density. Its position was carefully noted, to make sure it was not a comet. In December its brightness began to diminish, and it gradually passed through degrees of brightness until February, 1574, when it vanished, having been visible 17 months. Its color was first white, then yellow, and finally red. Some astronomers imagined that it would reappear again after 150 years, but it has never been discovered since. It alarmed the astronomers of the age who beheld it, and many of them wrote dissertations concerning it."

Amongst numerous other temporary stars that have from time to time appeared, the following may be quoted.

In 1604 a star appeared in Serpentarius and remained visible 15 months, then disappeared.

In 1848, in Ophiuchus, a star of the fourth magnitude appeared; in a few weeks it diminished to a star of the twelfth magnitude.

In May, 1866, a star of the second magnitude appeared in the northern crown. In June it was of the ninth magnitude.

La Place says of these phenomena: "As to those stars which suddenly shine forth with a very vivid light and then immediately disappear, it is extremely probable that great conflagrations, produced by extraordinary causes, take place on their surface. This conjecture is confirmed by their change of color, which is analogous to that presented to us on the earth by those bodies which are set on fire and then gradually extinguished." Mrs. Somerville says, "It is impossible to imagine anything more tremendous than a conflagration that could be visible at such a distance."

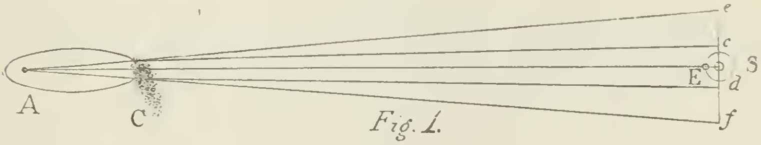


Fig. 1.

Presuming that in the course of time all possible relations in the positions of the heavenly bodies to each other must take place, we may assume that between a far distant and to us invisible sun, a comet may make a transit in such a position as to be directly in a line with the earth. Under such circumstances we will now consider the possible phenomena that would occur.

In Fig. 1, *A* represents such distant star, *S* our solar system, *E* the earth, and *C* a comet in the aphelion of its orbit about the star *A*.

Now if the nucleus and coma of the comet have density and transparency, both of which are probable, the rays of light emanating from the distant star *A* would suffer refraction, and the area represented by the line *e f*, which would be filled by the obstructing space of the comet, thus reduced in amount and inversely increased in intensity to the space $c\,d$, the ratio of $e\,f$ to $c\,d$ being dependent upon the refractive and dispersive power of the cometary mass.

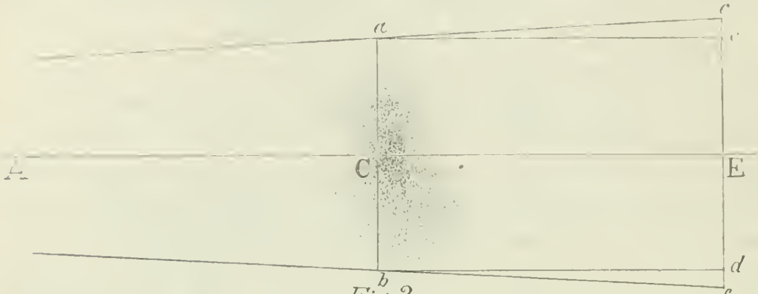


Fig 2.

Let us take Fig. 2 as an enlarged representation of the comet, in which A produced is the distant star and E the position of the earth. The amount of the normal rays that would be encountered by C may be represented by $\overline{a\,b}^2$ and at the earth by $\overline{e\,f}^2$, which by refraction will be represented by $\overline{c\,d}^2$. Call these respectively a^2, e^2 and c^2, and we may then have the proportion

$$\frac{a^2}{e^2} = \frac{\overline{C\,A}^2}{\overline{E\,A}^2} \qquad (1)$$

But the intensity of the variable light v, received by refraction at E, is to the normal light n inversely as $\overline{c\,d}^2$ is to $\overline{e\,f}^2$, or

$$\frac{e^2}{c^2} = \frac{v}{n} \qquad (2)$$

$$\therefore v = \frac{n\,e^2}{c^2}$$

Substituting the value of e in (1) we get

$$v = \frac{n\,a^2}{c^2}\,\frac{\overline{E\,A}^2}{\overline{C\,A}^2} \qquad (3)$$

In the event of refraction producing parallel rays from C to E, then $\overline{c\,d}$ being equal to $\overline{a\,b}$, or $c = a$, we have

$$v = \frac{n\;\overline{E\,A}^2}{\overline{C\,A}^2} \qquad (4)$$

Now the star α, Centauri, the nearest to our sun, is in round numbers 21 millions of millions of miles distant from it. Taking, as an illustration of the foregoing, the approximate magnitude and distance of a comet similar to that which passed through our system in 1680 as

Aphelion, . .	13,000,000,000 miles.
Perihelion, . . .	130,000 "
Velocity at perihelion, .	1,000,000 miles per hour.

According to (4), if such a comet should pass between that star and us under the foregoing conditions, $x = 2,600,000$, or it would increase two and a half million times the brightness of that star!

The relative brightness of a star of the first magnitude compared with one of the sixth magnitude, according to Herschel, is as 100 to 1. We may therefore form some conception what values in the equations (3) and (4) would bring a star from the sixth magnitude, or even from obscurity, to the first magnitude of brightness. But we are presuming on a dispersive power of the coma greater than it probably possesses. The usual cometary form of the nucleus and coma, if retained at that distance from its sun, would itself be conducive to a high dispersive power, and should the tail be retarded in its orbitual progress, causing the denser portion to be in advance of the centre of the comet, the sudden appearance of white light and its passage through the less refrangible rays, yellow and red, before extinction, would account for the phenomenon of a "burning out," as already described.

In regard to the period of duration of the phenomenon. In aphelion this comet would, according to the data given, possess a velocity of not greater than about ten miles per hour; and if its diameter were one-quarter that of the star, the time occupied in making a transit is easily reconciled, at least with the times of those variations of 1848 and 1866, and can easily be conceived to occupy a few weeks in duration.

Of course these illustrations are, for lack of data of the distances and actual magnitude of the fixed stars and comets, merely speculative attempts to reconcile the variations of the temporary stars with the transit of cometary masses, if at all reconcilable. We cannot conceive the vastness of the mechanism of this universe, which must ever exist in our imagination with the mere term infinite applied to it. As a speculation it appears more rational than the romance of the sudden destruction of entire systems by means of equally sudden and inconceivable conflagrations.

Although outside the bounds of pure science, speculative philosophy has often been the means of directing the course of investigation of truth. In the nature of such only has the foregoing been set forth. If some future observations on comets, specially directed to their materiality of composition, confirm the present notion, that they have density and transparency, that light in passing through their media suffers no refraction, then we must look for a new form, may be a fourth state of matter, in their constitution.

PRACTICAL ITEMS AND RECIPES.

By R. Grimshaw.

[These are in every case drawn from the compiler's personal experience, or obtained by him at first hand from those who have tested and approved them.]

To Conduct Ozonized Air use kerite tubing.

To Straighten Iron Wire and Light Rods.—Roll between two wide flat boards.

To Destroy Phylloxera, sprinkle the vines and saturate the soil with bisulphide of carbon.

Quick Dryer for Printers' Inks.—Use borate of manganese, which will also give a "gloss" effect.

Hardening Drills.—To give drills and other steel articles an unusual hardness, without brittleness, use mercury.

To Cut India Rubber Easily.—Keep the knife-blade wet with water, or, better still, with a strong solution of potash.

Very Porous Draining Tiles are made by mixing large quantities of sawdust with the plastic clay and burning as usual.

Springs of Tumbler Locks are best made of phosphor bronze, as preserving its toughness and elasticity and avoiding breakage or inaction.

To work Cork into symmetrical shapes, as pen handles, etc., cut approximately to shapes with a *greased* knife, using a drawing cut, and finish with a coarse emery wheel.

Hot Bearings are relieved and prevented by the use of graphite as a lubricator—either pure or well mixed in oil. This is good for the heaviest journals and highest speed.

Rubber Valves for Steam or for Oil, should be specially ordered for the purpose desired, as they require to be vulcanized at a higher temperature or for a longer time.

To PREVENT NICKEL-PLATING FROM SCALING off iron or steel objects, copper them first by battery or by simple immersion in a strong solution of sulphate of copper (blue vitriol).

CLEARANCE FOR NARROW SAW BLADES may be given, without either spring or spread set, by grinding the back to a knife edge. This is especially useful for keyhole, pruning and fret saws.

IN BUYING RUBBER GOODS, as car-springs, buffers, etc., *choose light ones;* heavy ones are loaded up with barytes, etc. Color is no test. Never buy old India rubber goods, as that material "perishes" with age.

THE HEATING OF HOT LINK BLOCKS is very common in steam fire engines of the Amoskeag and similar patterns. It may be avoided by substituting for the composition generally used lignum-vitæ or apple-wood blocks.

FILE HANDLES, to firmly hold double-ended or reversible saw-files, may be made by boring half-way down with a large bit, and deeply with a smaller one, thus giving the triangular file section a bearing at two places in its length.

TO GRIND VERMILIONS WITHOUT BROWNING THEM, use a mill having two rollers of diameters three to one, and the same number of revolutions per minute. They have a "slip motion," or true mulling action, and as there is only a line of contact, instead of a great surface, such mills grind cool and do not turn the color.

"FALSE BACK" UNION OR HOSE COUPLINGS are easily made, so true as to be nearly water tight without washers at ordinary pressures, by casting the male first with a square encircling groove, which, after being trued in the lathe and coated with charcoal blackwash, or with graphite, has the female portion cast around it.

TO "BRING UP" A SHORT CIRCULAR SAW TOOTH.—Sometimes one tooth strikes a knot, stone or spike, and loses only the tip end. Instead of filing the whole saw down to agree with the short tooth swage it with a crotched steel tool, gently lifting the tool as the hammer strikes it. This will raise the end, and bring the tooth into line.

TO PRESERVE LEATHER HOSE, BELTING, ETC., in good condition, freely apply crude castor oil, warmed if possible. It increases the pliability of the leather and the cling of belts; does not become rancid. Rats avoid it. In hose, it should be pumped in from the interior under considerable pressure, thus thoroughly filling the pores.

CHEAP SUCTION HOSE for wrecking purposes, bridge caissons, etc., may be made by sewing cotton duck into a tube of the desired diameter and springing into it a coil of stout galvanized iron wire, wound on a wooden or other mandrel, a trifle larger than the hose. The ends of the coil must be secured to the couplings. A coat of boiled linseed oil renders it water-tight.

GATES OR LOCKS FOR PNEUMATIC TUBING are best made, instead of with complicated valve chambers, ecc., by simply surrounding the terminus with a snug-fitting sleeve which has about 175° of its circumference removed throughout most of its length, to correspond with a similar opening in the tube. Semi-rotation, or lengthwise sliding, of the sleeve opens full or tightly closes the tube end.

COPYING INK, TO BE MADE WITHOUT PRESS OR WATER.—Well mix about three pints of jet-black writing ink and one pint of glycerine. This, if used on glazed paper will not dry for hours, and will yield one or two fair neat dry copies, by simple pressure of the hand, in any good letter copy book. The writing should not be excessively fine, nor the strokes uneven or heavy. To prevent "setting off," the leaves after copying should be removed by blotting paper. The copies and the originals are neater than where water is used.

DRAWING ON PHOTOGRAPHS.—Where it is desired to obtain an India ink drawing from a photograph, without resorting to tracing, very nice results are obtained thus: Prepare a print in the usual manner. Instead of toning as usual, fix immediately in "hypo." Wash well in running water to get out all the hypo. Draw directly on the print with India ink. This finished, bleach with a saturated solution of corrosive sublimate (bichloride of mercury) in equal parts of water and alcohol. Flowing is better than brushing, for applying the bleach, as it avoids smearing.

KEEPING WET PLATES FROM DRYING.—As dry plates are not always obtainable, and ordinary wet plates dry so quickly as not to allow transporting, it often becomes necessary, in order to make a single picture, to carry as much apparatus as would be required to make a dozen or more. A very good method of preparing a wet plate so as to last for several hours consists in flowing the plate (after taking out of the bath) with a mixture of one part of strong solution of silver (eighty grains to an ounce) and two parts chemically pure glycerine. Flow and drain the plate until all streaks disappear and the plate remains smooth. This dispenses with carrying the bath and useless chemicals. The plate may be developed on returning home.

Bone Glass.—After extracting phosphorus from bones, a glass can be formed from the residue, which consists of lime and phosphoric acid; the ordinary kinds of glass being composed of sand and potash, soda, lime and alumina. Bone glass can be worked as readily as any other glass. It has the valuable property of not being attacked by fluoric acid.—*Les Mondes.* C.

Petroleum in France and Italy.—A Franco-Italian company has been formed to explore Southern Europe for petroleum. Experts, with boring apparatus, have been brought from the United States, and the local authorities have promised liberal aid to the undertaking. The first wells are to be sunk at Tocco, in the Abruzzes, and at Rivanazzano, in Lombardy.—*Chron. Industr.* C.

Phoneidoscope.—M. Guebhard describes a method of projecting the colored rings which are produced on the surface of mercury by the breath or by a drop of volatile liquid. He also obtains membranous rings by substituting a drop of collodion or of varnish for the volatile liquid. These rings may be fixed upon a card and preserved indefinitely. Phoneidoscope figures may be obtained by pronouncing different sounds so that the breath may be intercepted by the mercurial surface.—*Soc. Franc. de Phys.*

Economical Fngineering in the St. Gotthard Tunnel.—Colladon enumerates the following advantages from the use of his compressors: 1. A saving of more than 600,000 francs ($120,000) in the simple purchase of compressors. 2. The reduction of the cost of buildings to about one-tenth of what would otherwise be required. 3. A ventilation so complete that the ventilating fans, which had been previously purchased, are entirely useless, and their whole cost might have been avoided.—*Mem. de la Soc. des Ing. Civils.* C.

Detection of Starch in Milk.—The adulteration of milk by starch can be readily detected by the following method. Add a few drops of acetic acid to a small quantity of the suspected milk; boil the milk, and after is has cooled filter the whey. If there is any starch in the milk, a single drop of iodine solution will give a blue tint to the whey. This process is so delicate that it will show the presence of a milligram of starch in a cubic centimetre of whey (1 grain of starch in 2·16 fluid-ounces of whey).—*La Gaceta Industrial.* C.

Packing for Steam Pipes.—J. Kathe makes a packing which also may be used as a non-conductor, for wrapping the pipes, by grinding 20 parts of hemp-refuse and mixing it in a Hollander with 40 parts asbestos, 20 parts wool-waste and 20 parts wood-pulp. The mass is then saturated with soluble glass and dried.—*Dingler's Journal.* C.

Prediction of Earthquakes.—J. Delauney has found, by examining the tables of earthquakes from 1705 to 1842, four groups of maximum frequency which occur when Jupiter and Saturn are at the mean longitudes of 265° and 135°. He therefore predicts an unusual number of earthquakes in the years 1886, 1891, 1898, 1900, 1912, 1919, 1927 and 1930.—*Comptes Rendus.* C.

Chlorophyll.—In 1877 Gautier prepared crystals of pure chlorophyll, and he has been studying its properties and affinities. A recent paper of Hoppe-Seyler has induced Gautier to announce his method of removing the impurities which vitiate most of the published observations. He finds numerous interesting resemblances to bilirubine and hematine, and anticipates, from further researches, results of great importance for vegetable physiology.—*Comptes Rendus.* C.

New Thames Tunnel.—A tunnel has been authorized by Act of Parliament between Greenwich and Millwall, two districts which have an aggregate population of 259,000 persons. When the ferry-boats are interrupted by the frequent fogs, a detour of about twelve miles has to be made in order to cross by way of London bridge. The new sub-way, which will be the fourth tunnel beneath the Thames, will be a third of a mile long, approached by a descent of fifteen steps at Millwall and by twenty-four steps at Greenwich.—*L'Ingen. Univ.* C.

Safety of Dynamite Cartridges.—Louis Roux says that the transport of dynamite should be entirely prohibited except when divided into small cartridges. When such cartridges are surrounded by some material, such as sand or sawdust, which absorbs any escaping liquid, perfect security may be obtained. In spite of the large quantity of dynamite manufactured during the last few years, not a single accident has occurred from transportation or storage. A box of dynamite cartridges may be let fall from a height great enough to break it, or crushed by the fall of heavy weights, or placed between the buffers of colliding railroad cars, without producing an explosion.—*Ann. du Gen. Civ.* C.

Electric Phenomenon.—E. Lamaire observed the following phenomenon during a snow-storm: The wind was blowing from E.S.E., the sky being very cloudy and the thermometer standing at 1° below zero (30·2°F.). At the beginning of a violent squall of snow little luminous points appeared at the extremity of each of the iron ribs of his umbrella, accompanied by a rustling similar to the buzzing of an insect. When he approached his ungloved hand to one of these points he felt a slight shock in the first two fingers, and the light disappeared. The experiment was repeated many times, and the phenomenon lasted four or five minutes, until the umbrella was covered with a thin coat of snow.—*Comptes Rendus.* C.

Proposed Circular Canal at Milan.—Perhaps no city of Italy has become more greatly benefitted by national independence than Milan. Among the schemes of public improvement which are attracting attention is the proposal of Francesco Ajraghi for a canal around the city. The estimated expense is 10,087,766 lire ($2,017,553.00). Among the proposed advantages are: 1. Increased facilities for the distribution and storage of commercial products. 2. Completion and extension of the system of irrigation. 3. A motive force of 6281 horse power, available for manufacturing. 4. Increased revenues from local imports of various kinds, from rents and from the sale of city lands. 5. A better and more abundant supply of excellent water for household use and for ornamental fountains. 6. Improved sanitary conditions, expecially in the suburbs.—*Il Politecnico.* C.

Calorific Effect of Steam Boilers.—Scheurer-Kestner estimates the loss of heat from the fire of a steam boiler, by radiation and conduction, at 25·5 per cent. Some writers say 40 per cent. As the loss has never been directly determined, but only estimated from the differences between other data which were imperfectly ascertained, these figures are very problematical. Ferdinand Fischer suggests experiments with combustibles of uniform composition, such as illuminating gas or petroleum, for determining calorific values and the various losses of heat. By adding the quantity of gas set free by combustion and elevated temperature, and taking account, by the help of Linde's formulas, of the specific heat which varies with the temperature, it would be possible to reach an accurate knowledge of the amount of heat trasmitted through the metal to the water of the boiler.—*Dingler's Journal.* C.

Franklin Institute.

Hall of the Institute, March 17th, 1880.

The stated meeting was called to order at 8 o'clock P.M., the President, Mr. William P. Tatham in the chair.

There were present 128 members and 44 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that 21 persons were elected members of the Institute at their last meeting.

The following donations to the Library are reported by the Secretary:

Report upon Forestry. By F. B. Hough. Washington, 1878.
From the Author.

Report of a Board of United States Naval Engineers on the Herreshoff Boiler.
From the Bureau of Steam Engineering, N. D., Washington, 1879.

Scientific Writings of James Smithson. Edited by W. J. Rhees. Washington, 1879.

Smithsonian Institution: Journals of the Board of Regents, Reports of Committees, etc. etc. Edited by W. J. Rhees. Washington, 1879.
From the Editor.

Germanischer Lloyd. Internationales Register, 1880.
From L. Westergaard & Co., Philadelphia.

Railroad Engineers' Practice, By Thos. M. Cleeman. New York, 1880.
From the Author.

Catalogue of Chambers Bros. & Co. Folding Machines, etc.
From C. Chambers, Jr.

Geographical Explorations and Surveys West of 100th Meridian. Topographical Atlas, 1875.
From the Dept. of the Interior.

Charter and By-laws, Report and Proceedings of the Numismatic and Antiquarian Society of Philadelphia. 1865 to 1879.
From the Society.

Fourth Annual Report of the Board of Trustees of the Pennsylvania Museum and School of Industrial Art. 1879.
From the Museum.

Methods and Results Standards of Measure of the United States compared with those of Great Britain and France. Washington, 1879.
From the U. S. C. and G. Survey.

Catalogue of the Library of the United States Naval Observatory. Washington. Part 1. Astronomy, Bibliogaphy. By Prof. E. S. Holden. 1879. From the Observatory.

Report on the Meteorology of Kerguelen Island. By S. J. Perry. London, 1879. From the Royal Society.

Annals of the Astronomical Observatory of Harvard College. Vol. 11. Part 2. From the College.

Resultados del Observatorio Nacional Argentino en Cordoba. B. A. Gould, Director. Vol. 1, 1879, and Atlas.
From the Observatory.

Annual Report of the Light-house Board to the Secretary of the Treasury for the year ending June 30, 1879.
From the Light-house Board.

Annual Report of Chief of the Bureau of Statistics on the Commerce and Navigation of the United States for the year ended June 30, 1877, and Part 1 of Foreign Commerce, 1878.

Annual Statements of the Chief of the Bureau of Statistics on the Commerce and Navigation of the United States for the fiscal year ended June 30, 1878. Part 2. Foreign Commerce.

Annual Statements of the Chief of the Bureau of Statistics on the Commerce and Navigation of the United States for the fiscal year ended June 30, 1879. Foreign Commerce.
From the Treasury Department, Washington.

United States Entomological Commission. Bulletin No. 3. The Cotton Worm. By Charles V. Riley.

Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. 5. No. 3. Washington.
From the Interior Department.

Report of the Meteorological Council to the Royal Society for the year ending 31st of March, 1879. London. From the Society.

Tenth Annual Report of the Board of Directors of City Trusts for 1879. From the Board.

The Duty on Steel Rails. The Case for the Manufacturers, at a Hearing before the Ways and Means Committee of the House of Representatives. Washington.

Memoir of Henry C. Carey. By William Elder.
From the American Iron and Steel Association.

Inter-Oceanic Canal Projects. Discussion before the American Society of Civil Engineers. From the Society.

Publications of the Cincinnati Observatory. No. 5.
Micrometrical Measurements of Double Stars. 1878 to 1879.
From the Observatory.

Official Army Register for January, 1880.
From the Adjutant-General's Office.

Joint Committee of the Councils of the City of Philadelphia on Commerce and Navigation, etc., etc. From Council.

Annual Report of the Commissioner of Agriculture for 1878.
From William G. Le Duc, Commissioner.

Historical Sketch of Henry's Contribution to the Electro-magnetic Telegraph. By William B. Taylor. Washington.
From the Author.

Annual Report of the Chief of the Bureau of Steam Engineering for 1879. Washington. From the Bureau.

Circulars of Information of the Bureau of Education. No. 5. 1879. Washington. From the Bureau.

Zweite Abhandlung über die Wasserabnahme in den Quellen, Flüssen und Strömen, etc. Von Gustav R. Von Wex. Wien, 1879.
From the Ostereich. Ingen. u. Architekten Verein.

United States Northern Boundary Commission. Declinations of Fixed Stars. By Lewis Ross. From the Dudley Observatory.

Report on the Madras Cyclone of May, 1877. By J. Elliott. Calcutta, 1879.

Report on the Administration of the Meteorological Department of the Government of India in 1877–78.

Report on the Meteorology of India in 1877. By John Elliot.
From the Meteorological Dep't Gov't of India.

Zur Kentniss der Fauna des Untersten Lias in den Nordalpen. Von Dr. M. Neumayer. From the K. K. Geolog. Reich't.

Catalogues, Circulars and Reports of the Pennsylvania State College of Agriculture. 1862 to 1879. From the College.

Mr. Louis H. Spellier read the paper announced for the evening, on "Electric Time Telegraphs."

The Secretary read the report of Prof. Henry Morton on the Tests made of the Electric Light at the Coney Island Pier in September last.

It was stated, in explanation of the purpose of this examination, that the Brush Company had agreed to give light of 2000 candle power, each with 22 horse-power, the small machine to run 900 revolutions per minute, the large one 750 revolutions per minute. They exceeded this speed four per cent. The twelve inch carbons used cost fifteen cents each, and the consumption was two inches per hour each.

Mr. McKean inquired what equivalent light in gas jets per horse-power was furnished, saying that so many "candles" was not as clear an expression as to volume of light as so many gas jets, with the power of which we are familiar.

At the request of the President, Prof. Rogers explained the manner of testing lights by comparison with standard candles, and mentioned a new means of testing lights for their color by establishing a standard of incandescent platinum heated by a battery of known power.

Mr. McKean expressed his thanks for the information as to candle power, but again repeated his question.

The President stated that it was only a matter of calculation. The average power of the lights was said to be 500 candles. There were 16 lights, giving an aggregate of 80,000 candles, by the expenditure of $21\frac{1}{2}$ horse-power, or nearly 400 candles per horse-power. From this the number of gas jets of given candle power could be calculated. He called attention to the fact that, while the large machine mentioned in Prof. Morton's letter required 1·35 horse-power per light, the smaller machine, running six lights for 4·3 horse-power, required only about ·71 horse-power per light.

Prof. Marks said that at Wannamaker's Depot there were 50 lights maintained by 65 horse-power, more than a horse-power for each light, and almost exactly the same as the results shown by the larger machine mentioned in Prof. Morton's letter. He said that at Edison's the light of only about 25 or 30 candles, he believed, was obtained per horse-power.

Prof. Rogers said that there was no doubt of the fact that the economy of power was enormously greater in the voltaic arc system than in the incandescent system of electric lighting. His estimate of the amount of light furnished at Edison's laboratory was a little higher than that of Prof. Marks—about 40 candles per horse-power—while that of the lamps mentioned in Prof. Morton's letter was 400 candles per horse-power, a difference of ten to one in favor of the voltaic arc. Economy cannot be obtained by the incandescent method.

Mr. Robert Briggs, taking as his text a paper on L. D'Auria's governor, published in another part of the JOURNAL, described the manner in which it operated, and repeated and endorsed the statements in the paper as to the governor being practically frictionless and isochronous.

Prof. William D. Marks, of the University of Pennsylvania, in describing a governor of his invention, said that it was possible to proportion the reciprocating parts of an engine so as to get very little variation on the crank pin. The next agent employed to secure steadiness is the fly-wheel, which will prevent a change of more than a certain amount during a stroke. Then the engine will go on gaining in speed, unless we employ a governor to prevent that. He did not believe there was such a thing as an absolutely isochronous governor. The cut-off governor so regulates the valve and cuts off steam in the cylinder that, whatever the variations of pressure and load may be (within limits), the engine will run at an approximately uniform speed. The throttling governor is the commonest form in use. With it there is a different velocity of governor with every change of pressure or of load. With every change of speed there is a different position of the governor ball and a different position of the valve. The governor changes constantly, always running a little faster or a little slower than the mean. It is constantly vibrating on either side of the mean, and this must be true as long as the laws of centrifugal force exist. The weight of the balls is constant, but as they spread outward the governor becomes less and less sensitive.

In my governor the pendulum spindle is in two sections. The lower one is capable of sliding lengthwise a little at the same time that it turns the upper one and screws up and down in the hub of its driving wheel. It is connected to the wheel by a spring, which operates to make the wheel overrun the spindle or the spindle overrun the wheel, according to whether the speed of the engine is increased or slackened. By this means the valve is closed or opened in advance of any change of speed in the pendulum. The sensitiveness of the governor depends upon the flexibility of the spring, its power to move the valve upon the pitch of the screws. The inertia of the governor balls is utilized to move the valve in advance of any change in the governor's speed, the inertia of the balls tending to close the valve when the engine attempts to increase its speed and the momentum of the balls opening the steam valve when the speed is decreased. The governor balls maintain a uniform speed, to which the engine conforms more or less closely according to the sensitiveness of the spring. No engine governor is isochronous in the scientific sense of the word, but this governor can be made to hold the engine very close to a standard speed and with little loss of power.

Mr. Briggs said that the Marks' Governor was of a different type from the D'Auria, and possessed advantages over the ordinary throttling governor. He thought that a first class engine must have a cut-off governor.

Mr. Nystrom said that it had been intimated that an isochronous governor could not be made. The water governor is practically isochronous, and he did not see why it could not be adapted to steam engines. The resistance of the air employed in Prof. Marks' governor was an old principle and had been heretofore used.

Prof. Marks said that he held the view that a governor could not be made absolutely isochronous, because it must change its speed before it could act. This is due to the fact that the degree of opening of the steam valve is directly controlled by the angle to which the governor balls are raised, the steam valve being moved only by a change of speed resulting from a change in the angle of suspension of the balls. A higher speed is necessary to reduce the supply of steam to meet a reduction of work.

Mr. Nystrom said he admitted that, but claimed that the variation could be made so slight as to make the governor practically isochronous.

Mr. Hugo Bilgram remarked that, in engines with cut-off governors, from the time of cut off to the same period of the next stroke, the governor exercised no control, and that if during that interval of time the load was decreased the speed of the engine would be increased. Within the period of about one revolution the governor is powerless.

The President.—The fly-wheel takes care of that.

Mr. Bilgram.—Yes, the fly-wheel and the governor are complementary and work together for that purpose. This closed the discussion, Prof. Marks answering queries as to his governor after the meeting, when it was shown in operation on the engine belonging to the Institute.

Mr. S. P. Burdict made a few remarks upon a large eight-day lever clock he exhibited, altered from a thirty-hour one originally made by the late Eli Terry, of Connecticut.

The Secretary's report included an account of Weaver's Metallic Envelopes for the safe transmission of articles in the mails; Hall's Health Syringe, in which nothing but air passes through the bulb and valves, which, pressing upon the liquid in the bottle, forces it out through a tube reaching to the bottom of the vessel; Butler's Electro type Ornaments, made from gutta percha moulds, for cabinet makers' use; Coppuck's Patent Car Coupling, an ingenious device enabling the brakesman to couple and uncouple cars without endangering his hands. Short papers were also read on Watson's invention to protect the body from extreme cold; Pneumatic Clocks; Uralium and the prices of rare metals; Cementing metals to glass; Artificial production of the Diamond; St. Gothard Tunnel; Photographic Etching on Copper, and the Carpet Trade of Philadelphia. Attention was also called to a fine painting of the Library Room of the Franklin Institute, on exhibition, the work of Mr. C. C. Cooper, Jr., of Germantown.

The Secretary announced the deaths of Mr. Wm. H. Howard, one of our early members, and Mr. John Richards. An obituary notice of the latter was read from *Engineering*.

Mr. Mitchell moved that a committee be appointed to prepare suitable resolutions of regret, and report at the next meeting, which was carried.

The President named the following standing committees for the year:

On the Library.—Chas. Bullock, Lewis S. Ware, Dr. Isaac Norris, Jr., Rob't Briggs, Henry Bower, Henry Pemberton, John H. Cooper, J. E. Mitchell, Jos. M. Wilson, Fred. Graff.

On Minerals.—Dr. F. A. Genth, Theo. D. Rand, Clarence Bement, Persifor Frazer, Jr., Dr. W. H. Wahl, E. J. Houston, Otto Luthy, E. F. Moody, Dr. G. A. Kœnig, H. Pemberton, Jr.

On Models.—C. Chabot, H. L. Butler, Edward Brown, M. L. Orum, J. Gœhring, L. L. Cheney, J. J. Weaver, S. Lloyd Wiegand, A. G. Busby, N. H. Edgerton.

On Arts and Manufactures.—J. J. Weaver, George V. Cresson, Hector Orr, Coleman Sellers, Jr., W. B. Le Van, Wm. Helme, J. S. Bancroft, Alfred Mellor, Cyrus Chambers, Jr., Geo. Burnham.

On Meteorology.—Pliny E. Chase, Hector Orr, Dr. Isaac Norris, Jr., David Brooks, Jas. A. Kirkpatrick, Alex. Purves, Dr. W. H. Wahl, F. M. M. Beale, H. Carville Lewis.

On Meetings.—H. Cartwright, Washington Jones, L. M. Haupt, W. L. Dubois, W. H. Thorn, Cyrus Chambers, Jr., J. J. Weaver, Fred'k Graff, Addison B. Burk.

On motion, the Institute adjourned.

ISAAC NORRIS, M. D., *Secretary*.

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NAVAL ARCHITECTURE.

No. 2.

By CHAS. H. HASWELL, C. E., M. E.
Member American Society of Civil Engineers.

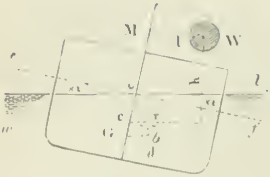
STABILITY.

Statical Stability is the moment of force which a body in flotation exerts to attain its normal position or that of equilibrium, it having been deflected from it, and it is equal to product of weight of fluid displaced and horizontal distances between the two centres of gravity of body and of displacement, or it is product of weight of displacement, height of *meta-centre* and sine of angle of inclination.

Dynamical Stability is amount of mechanical work necessary to deflect a body in flotation from its normal position or that of equilibrium, and it is is equal to product of sum of vertical distances through which centre of gravity of body descends and centre of buoyancy descends, in moving from vertical to inclined position by weight of body.

TO DETERMINE MEASURE OF STABILITY OF HULL OF A VESSEL OR OF A FLOATING BODY.

The measure of stability of a floating body depends essentially upon



horizontal distance, G *b*, of *meta-centre* of body from centre of gravity of the body; and it is product of the force of the water, or resistance to displacement of it, acting upward, and the distance of G *b*, or P × G *b*. If distance, *c* M, ir represented by *r*, and the angle of rolling, *c* M *r*, by M°, the measure of stability or S is determined by P *r*. sin. M° = S; and this is therefore greater, the greater the weight of the body, the greater the distance of *meta-centre* from centre of gravity of the body, and the greater the angle of inclination of this or of *c* M *r*.

Assume figure to represent transverse section of hull of a vessel, G centre of gravity of hull, *w l* water-line, and *c* centre of buoyancy or of displacement of immersed hull in position of equilibrium. Conceive the vessel to be heeled or inclined over, so that *e f* becomes the water-line, and *b* centre of buoyancy of the immersed section; produce *b* M, and the point M is *meta-centre** of the hull of the vessel.

Comparative Stability of different hulls or vessels is proportionate to the distance of G M for same angles of heeling, or of distance G *b*. Oscillations of hull of a vessel may be resolved into a rolling about its longitudinal axis, pitching about its transverse axis and vertical pitching, consisting in rising and sinking below and above position of equilibrium.

If transverse section of hull of a vessel is such that, when vessel heels, the level of centre of gravity is not altered, then its rolling will be about a permanent longitudinal axis traversing its centre of gravity, and it will not be accompanied by any vertical oscillations or pitchings, and the moment of its *inertia* will be constant while it rolls. But if, when hull heels, the level of its centre of gravity is altered, then axis about which it rolls becomes an instantaneous one, and the moment of its *inertia* will vary as it rolls; and rolling, must then necessarily be accompanied by vertical oscillations.

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* The transverse *meta-centre* depends upon position of centre of buoyancy, for it is that point, where a vertical line drawn from the centre, intersects a line passing through the centre of gravity of the hull of the vessel perpendicular to plane of the keel.

The point of *meta-centre* may be the same, or it may differ slightly for different angles of heeling. The angle of direction adopted to ascertain the position of the *meta-centre* should be the greatest which, under ordinary circumstances, is of probable occurrence; in different vessels this angle ranges from 20° to 60°.

If *meta-centre* is above the centre of gravity, the equilibrium is Stable; if it coincides with it, the equilibrium is Indifferent; and if it is below it, the equilibrium is Unstable.

Such oscillations tend to strain a vessel and her spars, and it is desirable, therefore, that transverse section of hull should be such that centre of its gravity should not alter as it rolls, a condition which is always secured if all water-lines, as *w l* and *e f*, are tangents to a common sphere described about G; or, in other words, if the point of their intersections, *o*, with the vertical plane of keel, is always equidistant from the centre of gravity of the hull.

TO COMPUTE STATICAL STABILITY.

$D \times e\,M \sin.\, M = S$, *D representing displacement, M angle of inclination, and S stability.*

Illustration 1. Assume a ship weighing 6000 tons is heeled to an angle of 9°, distance $e\,M = 3$ feet,

$$\text{Sin. } 9° = \cdot 1564.$$

Then $6000 \times 3 \times \cdot 1564 = 2815 \cdot 2$ *foot-tons.*

Illustration 2. Weight of a floating body is 5515 pounds, distance between its centre of gravity and *meta-centre* is 11·32 feet, and angle $M = 20°$.

$$\text{Sin. } M = \cdot 34202.$$

Hence $5515 \times 11 \cdot 32 \times \cdot 34202 = 21352 \cdot 24$ *foot-pounds.*

TO COMPUTE ELEMENTS OF STABILITY OF A FLOATING BODY.

$$\frac{A'}{A}\,a = s,\ \frac{e}{\sin.\, M} = r,\ \frac{s}{\sin.\, M} = g \text{ and } \sin.\, M\, r = e\,.$$

A representing area of immersed section; A′ section immersed by careening of body, as f o l; s horizontal distance c r, between centres of buoyancy; a horizontal distance between centres of gravity i i, of areas immersed and emerged by careening; g distance c M, between centre of buoyancy or of water displaced and meta-centre; r distance G M, between centre of gravity and meta-centre; e horizontal distance G b, between the centre of gravity and of line of displacement of it when careened, e vertical distance between centre of gravity and buoyancy, all in feet; and M angle of careening.

Note.—When centre of gravity G, is below that of displacement, *c*, then *e* is +; when it is above *c* it is —; and when it coincides with *c* it is 0; or *e* is — when $\frac{S}{P} < s$; and a body will roll over when $e \sin.\, M =$ or $> s$.

The assumed elements of figure illustrated are $A = 86$, $A' = 21{\cdot}5$, $b = 21{\cdot}5$ and $e = {\cdot}5$.

The deduced are $s = 3{\cdot}7$, $c = 3{\cdot}87$, $g = 10{\cdot}82$, $a = 14{\cdot}9$ and $r = 11{\cdot}32$, *b representing breadth at water-line or beam in feet and P weight or displacement in pounds or tons.*

The $s = \dfrac{21{\cdot}5}{86} \times 14{\cdot}8 = 3{\cdot}7$ feet, $r = \dfrac{3{\cdot}87}{{\cdot}34202} = 11{\cdot}32$ feet, $e = r - g$, $g = \dfrac{3{\cdot}7}{{\cdot}34202} = 10{\cdot}82$ feet, $c = {\cdot}34202 \times 11{\cdot}32 = 3{\cdot}87$ feet.

Of Hull of a Vessel.—$\left(\dfrac{b^3}{10{\cdot}7 \text{ to } 13^* A} \pm c\right) P, \sin. M = S$; $d \cos. {\cdot}5\, M = d'$, $\dfrac{b^3}{10{\cdot}7 \text{ to } 13\,(11{\cdot}93)\,A} = g$, $\dfrac{1}{\sin. M}\left(\dfrac{S}{P} - s\right) = \pm e$; $P\left(\dfrac{ba}{A} + \overline{c \sin. M}\right) = S$; and $P\,(s \pm \overline{c \sin. M}\,) = S$.

d representing depth of centre of gravity of displacement under water in equilibrium, and d′ the depth when out of equilibrium, all in feet.

ILLUSTRATION.—Displacement of a vessel is 10,000,000 pounds; breadth of beam, 50 feet; area of immersed section, 800 square feet; vertical distance from centre of gravity of hull up to centre of buoyancy or displacement, 1·9 feet, and horizontal distance a between centres of gravity of areas immersed and emerged, when careened to an angle of $9° \ 10'' = 33{\cdot}4$ feet, the immersed area being 50 square feet.

$$\sin. 9° \ 10'' = {\cdot}1593$$

Then $s = \dfrac{50}{800} \times 33{\cdot}4 = 2{\cdot}0875$ feet, $800 \times 2{\cdot}0875 = 50 \times 33{\cdot}4$,

$$r = \frac{2{\cdot}39}{{\cdot}1593} = 15 \text{ feet.}$$

$g = \dfrac{50^3}{11{\cdot}93 \times 800} = 13{\cdot}1$ feet, $S = \left(\dfrac{50^3}{11{\cdot}93 \times 800}\right) + 1{\cdot}9 \times 10{,}000{,}000 \times {\cdot}1593 = 23{,}905{,}396$ pounds, and $e = \dfrac{1}{{\cdot}1593}\left(\dfrac{23905396}{10000000} - 2{\cdot}0875\right) = 1{\cdot}9$ feet.

ILLUSTRATION 2.—Assume a ship having a displacement of 5000

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[*] Unit for the section of a parallelogram is 10·7; of a semicircle, 12, and of a triangle, 12·8.

tons and a height of *meta-centre* of 325 feet, to be careened to 6° 12′—what is her statical stability?

$$\text{Sin. } 6° \; 12' = {\cdot}1079$$

Then $5000 \times 3{\cdot}25 \times {\cdot}1079 = 1753{\cdot}37$ foot tons.

ILLULTRATION 3.—Assume a weight, W, of 50 tons to be placed upon her spar deck, having a common centre of gravity of 15 feet above her load-line.

Then $5000 \times 3{\cdot}25 - \overline{50 + 15} \times {\cdot}1079 = 1745{\cdot}29$ foot tons.

ILLUSTRATION 4.—Assume 100 tons of water ballast to be admitted to her tanks at a common centre of gravity of 15 feet below her load-line.

Then $5000 \times 3.25 + \overline{100 \times 15} \times {\cdot}1079 = 1915{\cdot}22$ foot tons.

ILLUSTRATION 5.—Assumeme her masts, weighing 6 tons, to be cut down 20 feet.

Then $\frac{10 \times 20}{5000} = \frac{2}{50}$ foot = fall of centre of gravity and $5000 \times \left(3{\cdot}25 = \frac{2}{50}\right) \times {\cdot}1079 = 1774{\cdot}95$ tons.

TO COMPUTE ELEMENTS OF POWER, ETC., REQUIRED TO CAREEN A BODY OR VESSEL.

$$\text{Sin. } M\,(h - \overline{n \text{ sin. } M}) + \overline{n \text{ sec. } M} - s = l$$

$$\frac{b^3}{10{\cdot}7 \text{ to } 13\,A}\;\sqrt[3]{\frac{P}{64{\cdot}125\,L\,A}} = m$$

$$W\,l\,r = P\,c \text{ and } W\,l = S.$$

W representing weight or power exerted and l distance at which weight or power acts to careen body taken from centre of gravity of displacement perpendicular to careening force, h vertical height from centre of gravity of displacement to centre of weight or power to careen body when it is in equilibrium, n horizontal distance from centre of vessel to centre of weight or power, L length of vessel and m meta-centre and S as in preceding case, all in feet.

ILLUSTRATION.—A weight is placed upon deck of a vessel at a mean distance of 3·87 feet from centre line of hull; height at which it is placed is 11·32, and other elements as in first case given.

$$\text{Sec. } 20° = {\cdot}342$$

Then $h = 11{\cdot}32$, $n = 3{\cdot}87$ and $l = {\cdot}342\,(1{\cdot}3 - \overline{3{\cdot}87 \times {\cdot}342}) + \overline{3{\cdot}87 \times 1{\cdot}0642} - 3{\cdot}7 = {\cdot}342 \times 10 + 4{\cdot}12 - 3{\cdot}7 = 3{\cdot}84$ feet.

Assume $W = 5515$.

Then $5515 \times 3{\cdot}84 = 21187{\cdot}6$ foot pounds.

Or $P\,(w \cos. M + h \sin. M) = S$, *$w$ representing distance of weight from centre of vessel and h height of w above water-line, both in feet.*

ILLUSTRATION.—If a weight of 30 tons placed at 20 feet from centre of hull or deck, 10 feet above water-line, careens it to an angle of 2° 9′, what is its stability?

$$\cos. 2^\circ\, 9' = {\cdot}9993 - \sin. 2^\circ\, 9' = {\cdot}0375$$

$$30\,(20 \times {\cdot}9993 + 10 \times {\cdot}0375) = 30 \times 20{\cdot}361 = 610{\cdot}83 \text{ foot tons.}$$

STATICAL SURFACE STABILITY.

Moment of statical surface stability at any angle is $c\,z \times D$. Assuming centre of gravity of vessel coincided with c, coefficient of a vessel's stability at any angle of heel is expressed when the displacement is multiplied by vertical height of the *meta-centre* for the given angle of heel above centre of gravity or $D \times c\,M$.

Approximately. RULE.—Divide moment of inertia of plane of flotation for the upright position, relatively to the middle line by volume of displacement; and quotient multiplied by sine of angle of heel will give result.

Per Foot of Length of Vessel, $\frac{2}{3}\,(B^3 \times \sin. M)$, *$B$ representing half breadth.*

DYNAMICAL SURFACE STABILITY.

Moment of dynamical surface stability is expressed by product of weight of vessel or displacement and depression of centre of buoyancy during the inclination, that is for angle M.

TO COMPUTE DYNAMICAL STABILITY OF A VESSEL.

Approximately. RULE.—Multiply displacement by height of *meta-centre* above centre of gravity and product by versed sine of angle of heel.

Or multiply statical stability for given angle by tangent of one-half angle of heel.

TABLE AND DIAGRAM FOR DETERMINING THE DIAMETERS OF SPEED CONES WHEN CONNECTED BY AN OPEN BELT OF CONSTANT LENGTH.

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The difficulty in the way of a short and accurate solution of this problem is the complex and transcendental nature of the equation which expresses the relation between the diameters of any belted pair of steps.

The equation itself is easily enough obtained from Fig. 1 as follows:

$$l = R\left(\frac{\pi}{2} + B\right) + r\left(\frac{\pi}{2} - B\right) + s\cos. B\,\frac{\pi}{2} \tag{1}$$

$$R - r = s\sin B \tag{2}$$

where l represents the half length of the belt.

In order that the belt may have equal tension on every pair of steps, it must be of constant length, consequently

$$l = R_1\left(\frac{\pi}{2} + B_1\right) + r_1\left(\frac{\pi}{2} - B_1\right) + s\cos. B_1 = R\left(\frac{\pi}{2} + B\right)$$
$$+ r\left(\frac{\pi}{2} - B\right) + s\cos. B \tag{3}$$

or
$$(R_1 + r_1)\frac{\pi}{2} + (R_1 - r_1)B_1 + s\cos. B_1 = R(R + r)$$
$$+ (R - r)B + s\cos. B \tag{4}$$

which last equation expresses the relation between the radii R_1 and r_1 of any pair of steps.

The data for determining the unknown diameters in the two cases occurring in practice are as follows:

Case I. Given all the diameters D, D_1, D_2 and D_3 on one cone A, one diameter d on cone B and the distance s between the axes.

Case II. Given the diameter D and d of one belted pair of steps, the ratios $\frac{D_1}{d_1}$, $\frac{D_2}{d_2}$ and $\frac{D_3}{d_3}$ of the diameters of the other pairs and the distance s between the axes.

If we now follow the usual method and reduce equations 2 and 4 to a single equation containing but one unknown quantity, by means of the data given either in Case I or Case II, we will get for both these cases

$$\sin. B - a B \sin. B + b \cos. B = c \qquad (5)$$

a, b and c being functions of known quantities. By developing sin. B and cos. B according to the ascending powers of the arc B,

$$\sin. B = B - \frac{B^3}{1.2.3} + \frac{B^5}{1.2.3.4.5} - \text{etc.}$$

$$\cos. B = 1 - \frac{B^2}{1.2} + \frac{B^4}{1.2.3.4} - \text{etc.}$$

and substituting in equation 5 we will get an equation that will contain powers of the arc B only, and which may be solved by any one of the well known trial methods. As soon as B is found its sine may be substituted in equation 2, and the required diameter obtained. But calculations by trial methods are tedious processes, even when all powers higher than the third are neglected, consequently graphical methods, based on the above series, have been devised for determining the required diameters, but these are only applicable within quite narrow limits, and even then are only approximately true.

That no table has hitherto been calculated for determining the diameters of speed cones is probably due to an idea that the above laborious or inaccurate methods were the only possible ones; but this is not the case, as the following explanation of how the writer obtained the present table will show:

Combining equations 1 and 2 we get

$$l = (R + r)\frac{\pi}{2} + s B \sin. B + s \cos. B \qquad (6)$$

which is easily transformed into

$$\frac{l}{s} = \frac{\pi}{4}\,\frac{D+d}{s} + B \sin. B + \cos. B \qquad (7)$$

and this again into

$$\frac{D+d}{s} = \frac{2}{\pi}\,\frac{L}{s} - \frac{4}{\pi}(B \sin. B + \cos. B) \qquad (8)$$

where $\frac{D+d}{s}$ may be regarded as the sum of the diameters of any belted pair, and $\frac{L}{s}$ the whole length of belt when the distance between the axes is unity.

It is evident that there can be calculated from equation 8 a table of values of $\frac{D+d}{s}$ corresponding to assumed values of $\frac{2}{\pi}\frac{L}{s}$ and $\frac{4}{\pi}(B \sin. B + \cos. B)$ as arguments, provided these latter are kept within the limits of the problem. Now an inspection of Fig. 1 will show that these limits are as follows:

For the angle B — 0° and 90°
" sin. B — 0 and 1·
For $\frac{4}{\pi}(B \sin. B + \cos. B)$ — 1·273 and 2·
and corresponingly for $\frac{L}{s}$ — 2 and 6·283
" $\frac{2}{\pi}\frac{L}{s}$ — 1·273 and 4·

Within these limits we have considerable range in our choice of values for the arguments, and may therefore choose them so that the tabular differences for adjacent values of $\frac{2}{\pi}\frac{L}{s}$ shall equal some constant number, as ·100 or ·200, for this will not only facilitate interpolation, but will greatly reduce the number of terms to be calculated from the formula. In calculating the accompanying table, therefore, the successive values of $\frac{2}{\pi}\frac{L}{s}$ differ by 0·200, and those of $\frac{4}{\pi}(B \sin. B + \cos. B)$ in such a manner that $\frac{D-d}{s} = 2\frac{R-r}{s} = 2 \sin. B$ was successively equal to 0, 0·1, 0·2, etc. The next step was to substitute in the table for $\frac{D+d}{s}$ the separate values $\frac{D}{s}$ and $\frac{d}{s}$, these being determined from the well known relations:

$$D = \frac{D+d}{S} + \frac{D-d}{S} \qquad d = \frac{D+d}{S} - \frac{D-d}{S}$$

and then write $\frac{L}{s}$ for $\frac{2}{\pi}\frac{L}{s}$ and $\frac{D-d}{s}$ for $\frac{4}{\pi}B \sin. B + \cos. B$. The table was then completed.

Now although the length of belt enters into the computation of the table and has been placed in the latter as an argument, it need not be known to solve either Case I or Case II. The object of placing it in the table was simply to indicate the series of belted pairs having the same length of belt. It should also be remembered that the preceding formulas take no account of thickness of belt, consequently both the given and required diameters must be regarded as extending to the centre of the belt.

We can best show how this table is to be used by the following examples:

Example 1.—Given the four diameters, 4″, 8″, 14″, 20″ on cone A,
one diameter, — — 14″, — on cone B,
and the distance between the axes equal to 40″.

Required the remaining diameters of the steps on cone B.

The given pair consisting of equal steps, we have $\frac{D-d}{s} = \frac{14-14}{40} = 0$, and must therefore look along the first horizontal series of pairs for the diameter $\frac{14}{40} = \cdot 350$, in order that we may find the column corresponding to the length of belt connecting these particular cones. The quantity ·350 evidently lies half way between columns 3 and 4, and corresponds to a length of belt $\frac{L}{s} = \frac{2\cdot 944 - 3\cdot 258}{2} = 3\cdot 101$. As the differences between the adjacent values of columns 3 and 4 are everywhere ·100, we can get, if desired, another column corresponding to the length of belt, 3·101, by simply adding ·050 to all the values in column 3, thus getting the series of pairs

·350	·399	·447	·493	·537	·580
·350	·299	·247	·193	·137	·080

the upper and lower rows corresponding respectively to the larger and smaller diameters of the pairs. To get the other member of the belted pair to which the 4″ step belongs we must look for $\frac{4}{40} = 1\cdot 100$ along the lower row of this series and will find that the next lower term is ·080, and then interpolating we obtain for the ratio of the required diameter to distance of the axes

$$\cdot 580 - (\cdot 100 - \cdot 080)\,\frac{43}{57} = \cdot 565$$

Multiplying this ratio ·565 by 40″ gives 22·6 for the required diameter. Proceeding in the same manner for the next step, we have, since $\frac{8}{40} = .200$.

Table containing the EFFECTIVE *Diameters of the Companion Steps of Speed Cones, for Constant Lengths of Open Belt, and for Axes a Unit's Distance Apart.*

Diff. of Diams. of steps $\frac{D-d}{s}$	$\frac{L}{s}$ 2·316	2·630	2·944	3·258	3·572	3·886	4·200	4·514	4·828	5·142	5·456	Differences.	Contact of Belt on smaller Step. α.
	1	2	3	4	5	6	7	8	9	10	11		
0·0	·100 ·100	·200 ·200	·300 ·300	·400 ·400	·500 ·500	·600 ·600	·700 ·700	·800 ·800	·900 ·900				180°
												49 51	
0·1	·149 ·049	·249 ·149	·349 ·249	·449 ·349	·549 ·449	·649 ·549	·749 ·649	·849 ·748	·949 849	1·049 ·949			174°
												48 52	
0·2		·297 ·097	·397 ·197	497 ·297	·597 ·397	·697 ·497	·797 ·597	·897 ·697	·997 ·797	1·097 ·897			169°
												46 54	
0·3		·343 ·043	·443 .143	·543 ·243	·643 ·343	·743 ·443	·843 ·543	943 ·643	1·043 ·743	1·143 ·843			163°
												44 56	
0·4			·487 ·087	·587 ·187	·687 ·287	·787 ·387	·887 ·487	·987 ·587	1·087 ·687	1·187 ·787			157°
												43 57	
0·5			·530 ·030	·630 ·130	·730 230	·830 ·330	·930 ·430	1·030 ·530	1·130 ·630	1·230 ·730			151°
												41 59	
0·6				·671 ·071	·771 ·171	·871 ·271	·971 ·371	1·071 ·471	1·171 ·571	1·271 ·671			145°
												40 60	
0·7				·711 ·011	·811 ·111	·911 ·211	1·011 ·311	1·111 ·411	1·211 ·511	1·311 ·611			139°
												37 63	
0·8					·848 ·048	·948 ·148	1·048 ·248	1·148 ·348	1·248 ·448	1·348 ·548			133°
												36 64	
0·9						·984 ·084	1·084 ·184	1·184 ·284	1·284 ·384	1·384 ·484			127°
												35 65	
1·0						1·019 ·019	1·119 ·119	1·219 ·219	1·319 ·319	1·419 ·419			120°
												32 68	
1·1							1·151 ·051	1·251 ·151	1·351 ·251	1·451 ·351			113°
												31 69	
1·2								1·282 ·082	1·382 ·182	1·482 ·282	1·582 ·382		106°
												28 72	
1·3								1·310 ·010	1·410 ·110	1·510 ·210	1·610 ·310		99°
												26 74	
1·4									1·436 ·036	1.526 ·136	1·636 ·236		91°
												25 75	
1·5										1·561 ·061	1·661 ·161		83°
												21 79	
1·6											1·682 ·082		74°
												20 80	
1·7											1·702 ·002		64°

$$\cdot493 - (\cdot200 - \cdot193)\,\frac{46}{54} = \cdot487$$

for the required ratio. $\cdot487 \times 40 = 19\cdot48$, the required partner of the 8″ step.

Interpolating in like manner for the 20″ step, $\frac{24}{40} = 0\cdot5$ being looked for however in the upper row of our series, we get

$$\cdot193 - (\cdot500 - \cdot493)\,\frac{56}{44} = \cdot184,$$

which, multiplied by 40, gives 7·36 for the companion of the 20″ step.

The belted pairs of our two cones are therefore as follows:

4	8	14	20	on cone *A*,
22⅝	19½	14	7⅜	" " *B*.

The next example gives a shorter method of obtaining the required diameters, and differs from the preceding problem in having the steps of the given belted pair of unequal, instead of equal, diameters.

Example 2.—Given the diameters 6, 12, 18, 24 on cone *B*,

Given the diameters	6,	12,	18,	24	on cone *B*,
diameter	32,	—	—	—	" " *A*,

and the distance between the axes = 50″.

Required as before the unknown diameters of *B*.

Here $\frac{D-d}{s} = \frac{32-6}{50} = \cdot520$ means that we must look between the 6th and 7th horizontal series of pairs for $\frac{6}{50} = \cdot120$, in order that we may find the column corresponding to the length of belt on these cones. Interpolating between the lower rows we find

$$\cdot120 - \left[\cdot130 - (\cdot52 - \cdot50)\,\frac{59}{100}\right] = \cdot002$$

as the quantity which must be added to column 4 in order to obtain the tabular series corresponding to the length of belt in the present case; this series obtained we could proceed as in first example. But we can also obtain the required results without finding this series, namely, as follows: Look for $\frac{12}{50} - \cdot002 = \cdot238$ in column 4 and find the corresponding difference $\frac{D-d}{s}$ of the diameters of this belted pair in the column at the left of the table by the following interpolation:

$$\frac{D_1 - d_1}{s} = 0{\cdot}3 + ({\cdot}243 - {\cdot}238)\,\frac{100}{59} = {\cdot}309$$

Multiplying this difference by 50 and adding the product to 12 we get, for the partner of the latter, $27\frac{7}{16}''$. In like manner the fellow of the 18″ step may be obtained by finding the difference $\frac{D_2 - d_2}{s}$ corresponding to $\frac{18}{50} - {\cdot}002 = {\cdot}358$ of column 4.

$$\frac{D_2 - d_2}{s} = 0{\cdot}0 + ({\cdot}400 - {\cdot}358)\,\frac{100}{51} = {\cdot}082$$

then multiplying this difference by 50 and adding the product to 18, the sum $22\frac{1}{8}''$ is the diameter of the required step. For the partner of 24″ step we must look for $\frac{24}{50} - {\cdot}002 = {\cdot}478$ among the larger members of the pairs in column 4. Its corresponding difference will be

$$\frac{D_3 - d_3}{s} = 0{\cdot}1 + ({\cdot}478 - {\cdot}449)\,\frac{100}{48} = {\cdot}160$$

The product of this difference by 50 *subtracted* from 24″ gives 16 as the diameter of the required step.

The belted pairs of the speed cones will then be as follows:

6	12	18	24
32	$27\frac{7}{16}$	$22\frac{1}{8}$	16

From the last column of the table can be obtained, if desired, the arc of contact of belt on the smaller step; for the above pairs they are as follows:

$\alpha = 150°$ 162° 175° 17[illegible]°

and from the top of the table we get for the length of belt

$$50\left(3{\cdot}258 + \frac{{\cdot}002}{{\cdot}100} \times {\cdot}314\right) = 163''$$

Example 3.—Given the number of revolutions of speed cone $A = 240$, and the distance between the axes = 40″.

Required that the steps be so chosen that the cone B may make 100, 240, 400 and 580 revolutions per minute.

If we assume that 30 feet per second would be a suitable maximum velocity of belt on these speed cones, and that D is the diameter of the step on cone A, which transmits 580 revolutions to the step d on cone B, we will get from

$$\frac{D}{12} \times 3{\cdot}14 \times \frac{240}{60} = 30$$

$$D = 29'' \text{ nearly and } d = \frac{240}{580} \times 29'' = 12''$$

We can now make use of the table, first finding, as in the previous examples, the column corresponding to the length of belt connecting D with d. Since $\frac{D-d}{s} = \frac{29-12}{40} = {\cdot}425$, we must look between the 5th and 6th horizontal series of pairs for $\frac{12}{40} = {\cdot}300$, and will then find that it lies in a series obtained by adding

$${\cdot}300 - \left[{\cdot}287 - ({\cdot}425 - {\cdot}400)\,\frac{57}{100}\right] = {\cdot}027$$

to the values of column 5. Along the series of pairs thus obtained we must now look for the particular pair

$${\cdot}597 + {\cdot}027 = {\cdot}624$$
$${\cdot}397 + {\cdot}027 = {\cdot}424$$

whose diameters bear to each other a ratio most nearly equal to $\frac{D_1}{d_1} = \frac{400}{240} = \frac{5}{3}$. If to the numerator of this next lower ratio $\frac{{\cdot}624}{{\cdot}424}$ we add the proper fraction of the tabular difference between the larger diameters and subtract from the denominator the same fraction of the tabular difference between the smaller diameters, the resultant ratio will equal the required one, or if x represents the aforesaid proper fraction we must have

$$\frac{D_1}{d_1} = \frac{{\cdot}624 + x \times {\cdot}046}{{\cdot}424 - x \times {\cdot}054} = \frac{5}{3}$$

We have now only to solve this equation of the first degree with respect to x and then substitute x in the fraction constituting its first member, in order to find that in the numerator we have the larger and in the denominator the smaller member of the required pair. x is here equal to 0·61, consequently $\frac{D_1}{d_1} = \frac{{\cdot}652}{{\cdot}391}$ and $D_1 = {\cdot}652 \times 40 = 26{\cdot}08$ and $d_1 = {\cdot}381 \times 40 = 1564$.

In like manner we can first find x and then D_3 and d_3 from

$$\frac{d_3}{D_3} = \frac{240}{100} = \frac{{\cdot}687 + {\cdot}027 + x \times {\cdot}043}{{\cdot}287 + {\cdot}027 - x \times {\cdot}057}$$

x being here equal to 0·22.

$$\frac{d_3}{D_3} = \frac{{\cdot}723}{{\cdot}301} \qquad d_3 = {\cdot}723 \times 40 = 28{\cdot}92 \text{ and } D_3 = {\cdot}301 \times 40 = 12{\cdot}04$$

Since $\frac{D_2}{d_2} = \frac{240}{240} = 1$, we easily find $D_2 = d_2 = (500 + {\cdot}027) \times 40 = 21{\cdot}08$.

The required pairs are, therefore, as follows:

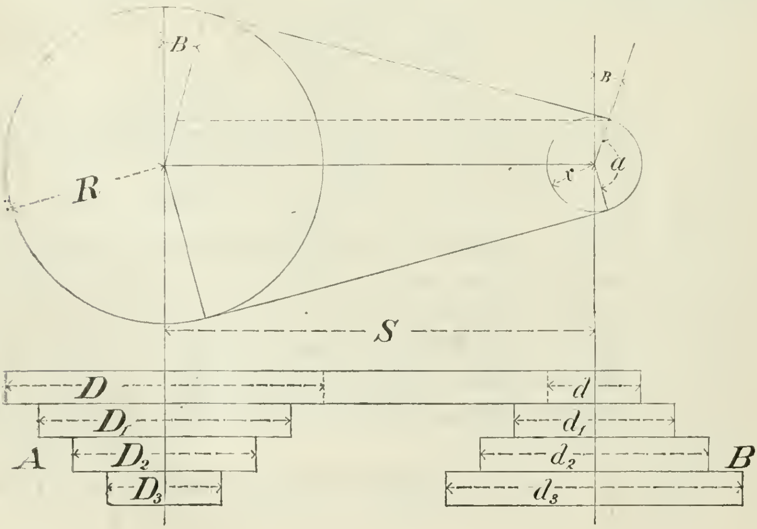
12·04	21·08	26·08	29	on cone *A*
28·92	21·08	15·64	12	“ *B*

The blank spaces of the table represent impossible cases. It should, also, be noticed that for differences $\frac{D-d}{s} < {\cdot}2$, the sum of the diameters, is nearly constant; consequently, if the greatest difference between the companion steps of a pair of cones does not exceed 0·2 *s*, we may calculate the diameter of these cones as if they were connected by a crossed belt, that is, as if the sum of the diameters was constant.

Besides the foregoing table, the writer has also calculated another, in which the ratio of one of the diameters of a belted pair to the distance between the axes is assumed, and its partner colculated for different lengths of belt, the assumed diameters forming an arithmetical series, whose first term is ·05 and whose difference is also ·05. This last table, though apparently simpler than the one here given, is not so convenient for interpolation.

For those who do not interpolate readily we have added the diagram explained below.

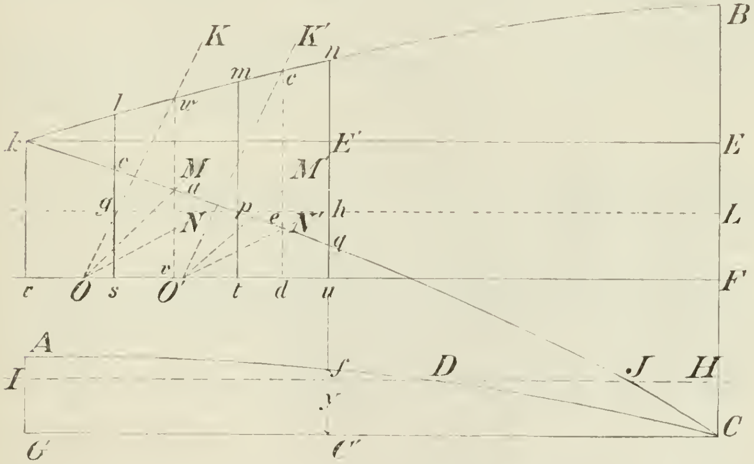
Fig. 1.



Of all the graphical methods which have been devised for solving the speed cone problem, that of Prof. Culmann is the only one which is exact; it is, moreover, the only one which possesses the time-saving property of needing to be constructed but once in order to be applicable to every speed cone problem which may arise in practice. The only objection to be made to Culmann's diagram is, that though easy of application, and not difficult to understand, it nevertheless requires considerable time and care for its accurate construction. The writer has sought to remove this objection to the diagram by calculating the ordinates of the curve forming its essential feature.

Reversing the usual methods of presenting these subjects, we will first show how this curve is to be used in solving speed cone problems, then how the ordinates may be calculated, and finally will explain Cullmann's method of constructing the curve.

Fig. 2.



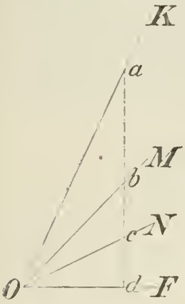
In Fig. 2 each one of the vertical chords, as *ol*, represents the difference between the diameters of some belted pair of steps, the greatest possible vertical chord, *BC*, being equal to 2 *s*, or twice the distance between the axes. Both the given and required diameters are estimated from some horizantal line, as *rF*, which we call the datum line. The different positions of the datum line correspond to different lengths of belt.

Now suppose we had given all the diameters of cone *A*, one diameter of cone *B*, and the distance 2 *s* between the axes.

If we now take BC, Fig. 2, as the linear representative of $2s$, and to the same scale $\frac{MT}{PT}$ OS, RR and NU as the linear equivalents of the given diameters, we can find the required partners of OS, RR and NU by the following process. We first find (by trial) that vertical chord mp of the curve BkC, which is equal to the difference $MT—PT$ of the diameters of the given pair; from the lower end of the chord thus found we then lay off pt, equal to the smaller diameter PT of the given pair, and through t draw the horizontal or datum line rtF. To find the companion of OS we have simply to find the point o on the curve BkC, whose distance os from the datum line rtF is equal to OS; then, drawing a vertical line through o, we will have in ls the required diameter to the scale $\frac{BC}{2s}$. Form the companion step to KR we obtain its equal, kr, the difference between the members of the belted pair being in this case equal to zero. For the partner of NU we obtain nu.

If, as in Example 3, we had given one pair of diameters, and the ratios $\frac{2}{1}$, $\frac{4}{1}$, of the remaining pairs, we would, as in the previous example, first find that vertical chord of the curve BkC which is equal to the difference of the given diameters, and, as before, lay off the smaller diameter to obtain the datum line from which diameters are estimated. When the datum line has been located, we can easily find the diameters having the required ratios, either by trial or as follows: Draw, Fig. 3, any convenient angle, KOF; then bisect any vertical line, ad, included in it, at b, also bd at c; then will $\frac{ad}{bd} = \frac{2}{1}$ and $\frac{ad}{cd} = \frac{4}{1}$, and any line parallel to ad will be divided in the same proportion by the rays OF, ON, OM and OK. Now, if Fig. 3 had been drawn on some such transparent material as tracing cloth, the line OF might be placed upon and moved along the datum line rF, Fig. 2, till the respective intersections of the rays OK and OM, with the upper and lower branches of the curve BkC, were in the same vertical line, as at wa, Fig. 2; then would wr and ar be the diameters having the required ratio $\frac{wr}{ar} = \frac{2}{1}$. Moving OF of Fig. 3 still further along the datum line rF of Fig. 2, we would obtain in like manner the diameters cd and ed with the required ratio $\frac{cd}{ed} = \frac{4}{1}$.

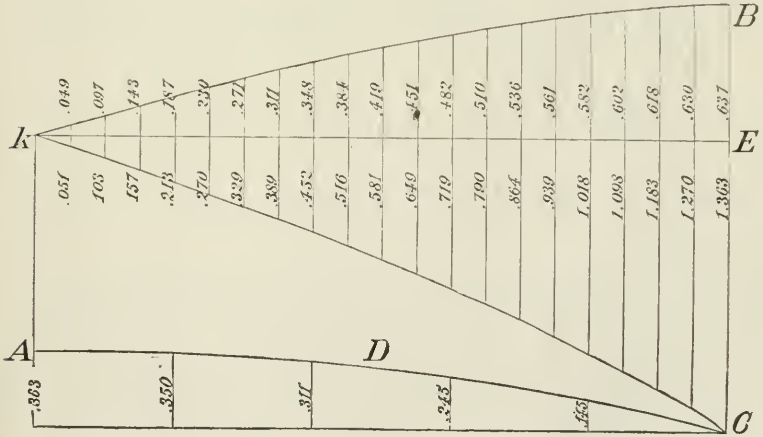
Fig. 3.



As the sum of the radii of the steps cannot be greater than the distance between the axes, there is evidently a limit to the size of the steps for every given difference of diameters; these limits taken together form another curve, CDA, Fig. 2. The vertical lines qf and nf included between this curve and the two branches of BkC are the maximum diameters for the given difference nq, for $qf = nf = BC = 2s$.

It follows from this, that only from that portion of the datum line DH which falls above the limiting curve CDA can diameters be estimated. But even the portion DH cannot be wholly thus used, for there is still another very evident condition, namely, that the diameters can never be less than zero, consequently it is only from the portion DJ of the datum line HI that diameters can be estimated.

Fig 4.



We have given in Fig. 4 the ordinates of the upper and lower branches of the curve BkC shown in Fig. 2. The ordinates were chosen so that the chords or differences of diameter should form an arithmetical series whose first term was 0 and difference 0·1. These ordinates were made equidistant on Fig. 4 as a matter of convenience, only, for the diagram gives correct results even when the increments of the abscissas are not constant, the reason of this being that, since both data and results are vertical quantities, any amount of *horizontal* distortion is permissible which allows the chords to remain vertical.

We will now explain how the ordinates of Fig. 4 were calculated. Equation 4 was first transformed into

$$\frac{D_1-d}{s}=\frac{1}{\pi}\bigg(\frac{D-d}{s}\left(\frac{\pi}{2}+B\right)+2\cos. B-\bigg[\frac{D_1-d_1}{s}\left(\frac{\pi}{2}+B_1\right)+2\cos. B_1\bigg)\bigg] \qquad (9)$$

when $\frac{D-d}{s}$ is the given difference mp, Fig. 2, and $\frac{d}{e}$ the given smaller diameter pt, determining the datum line rF, and as $\frac{D_1-d_1}{s}$ is any other difference of diameters lo, $\frac{D_1-d}{s}$ must represent such lines og or lg, or the distance of the curve BkC from the line gL, drawn through the foot of the vertical chord mp. By taking $\frac{D-d}{s}=o$, the horizontal line gL changes into kE, and Equation 9 simplifies to

$$\frac{D_1-d}{s}=\frac{1}{\pi}\left[2(1-\cos. B_1)-\frac{D_1-d_1}{s}\left(\frac{\pi}{2}+B_1\right)\right] \qquad (10)$$

$\frac{D_1-d}{s}$ now representing the ordinates of the curve measured from kE.

Assuming $\frac{D_1-d_1}{s}$ or $\frac{d_1-D_1}{s}$ successively equal to 0·1, 0·2, 0·3, etc., we have

$$\text{Sin. } B_1=\frac{1}{2}\,\frac{D_1-d_1}{s} \text{ successively equal to } 0{\cdot}05,\ 0{\cdot}10,\ 0{\cdot}15, \text{ etc.}$$

and from tables of sines, cosines and arcs we can get the corresponding values of cos. B_1 and B_1. These substituted in Equation 10 will completely determine the required ordinates $\frac{D_1-d}{s}$ of the curve BkC.

The ordinates of the curve ADC, Figs. 2 and 4, are are now also easily obtained from

$$y=E^1C^1-(E^1q+qf)=1{\cdot}363-\left[\frac{D_1-d}{s}+\left(1-\frac{D_1-d_1}{2s}\right)\right] \quad (11)$$

We have thus far only stated the essential features of Culmann's diagram, without attempting to prove them, and will now seek to make this omission good by showing that the diagram can be obtained by finding the linear equivalents of the following equations,

$$R=\frac{l}{\pi}-\frac{s}{\pi}\,(B\sin.B+\cos.B)+\frac{s}{2}\sin.B \qquad (12)$$

$$r=\frac{l}{\pi}-\frac{s}{\pi}\,(B\sin.B+\cos.B)-\frac{s}{2}\sin B \qquad (13)$$

obtained by combining Equations 1 and 2.

Fig. 5.

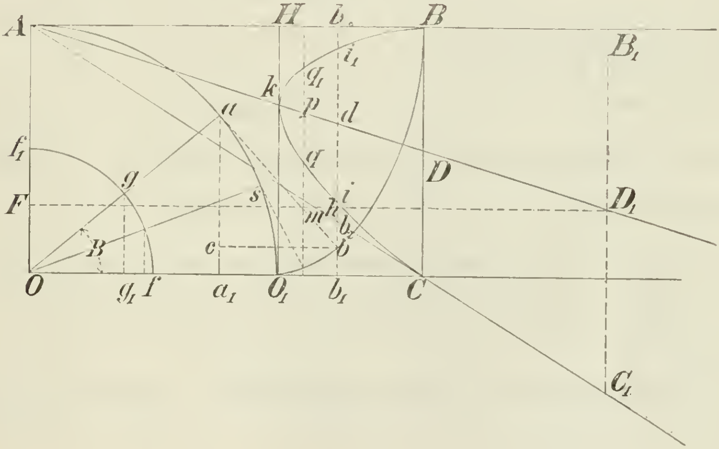


Fig. 5 is taken from Reuleaux's *Constructionslehre*, page 610, where a very clear explanation of the diagram is given. It is, briefly, as follows: With a radius $OA=s$ (the distance apart of the axes) describe the quadrant O_1A; then construct its involute, O_1B, and let fall from B the perpendicular BC on to OO_1 produced; then will $AB=OC_1=\frac{s\pi}{2}$ for $<AOO_1=90^\circ=\frac{\pi}{2}$. Since $BC : AB :: s : \frac{s\pi}{2}$ we have

$$BC=\frac{2}{\pi}AB$$

Bisecting BC at D, we have $BD=\frac{AB}{\pi}$ and $BD=D_1C_1=\frac{AB}{\pi}$

Now, if we choose $AB_1 = l$, we shall have for the linear equivalent of the first term $\frac{l}{\pi} - B_1 D_1 = D_1 C_1$.

Now let a radius, Oa, make with OO_1 any angle, B, less than 90°, and drop the perpendicular ad_1 from a; then will $Oa_1 = Oa \cos. B = s \cos. B$. Now draw a tangent to the quadrant at a; it will cut the involute at b, and its length $ab = aO_1 = sB$. Since $< a_1, ab = B$, we have

$$bc = a_1 b_1 = ab \sin. B = sB \sin. B,$$

and therefore $b_1 O = (b_1 a_1 + a_1 O) = s\,(B \sin. B + \cos. B)$.

Prolonging $b_1 b$ till it intersects AB at b, we have again, as above,

$$db_0 = db_2 = \frac{Ab_0}{\pi} = \frac{b_1\ O}{\pi} = \frac{s}{\pi}\,(B \sin. B + \cos. B$$

or $db_0 = db_2$ are each of them the linear equivalents of the second term of the above equations.

There remains now only the third or last term, $\frac{s}{2} \sin. B$, which is added in the first equation, but subtracted in the second. Its linear equivalent is easily found by describing with radius $Of = \frac{s}{2}$ the quadrant ff, and from the intersection g of the latter with the radius Oa dropping a perpendicular, gg, on to OO_1; then will $gg = Og \sin. B = \frac{s}{2} \sin. B$. The equivalents of the separate terms having been ascertained, we have now only to combine them. For this purpose we draw AF parallel to $B_1 A$, cutting $b_0 b_1$ at h; then, since $h b_0 = D_1 B_1 = \frac{b}{\pi}$ we will have

$$dh - hb_0 - db_0 = \frac{l}{\pi} - \frac{s}{\pi}\,(B \sin. B + \cos. B)$$

for the combination of the first and second terms.

Now, making $di = di_1 = gg = \frac{s}{2} \sin. B$, we will have

$$R = hi_1 = dh + di_1 = \frac{l}{\pi} - \frac{s}{\pi}\,(B \sin. B + \cos. B) + \frac{s}{2} \sin. B$$

$$r = hi = dh - di = \frac{l}{\pi} - \frac{s}{\pi}\,(B \sin. B + \cos. B) - \frac{s}{2} \sin. B$$

for a particular value of the angle B. Other angles of B will give different values for the radii R and r; for example, if we retain the same length, l, the same angle, $O_1 Os = B_1$, will give for the larger diameter $R_1 = mq$, and for the smaller diameter $r_1 = mq$. Connecting the points i, i_1, q, q, etc., we obtain a curve, BkC, which needs to be constructed but once, for it will not vary with l, because $di = di_1 = \frac{s}{2}$ sin. B are independent of l.

Since the radii R, r, R_1 and r_1 are constructed to the same scale as the distance $BC = s$ between the axes, it is evident that the ratios $\frac{R}{s}$, $\frac{r}{s}$, $\frac{R_1}{s}$, $\frac{r_1}{s}$, etc., obtainable from this diagram are applicable to all distances apart of the axes. The curve BkC, as given in Fig. 5, is not, however, of convenient shape for practical use; it may, therefore, be distorted horizontally, in such a way that the vertical chords remain vertical, which is easily done by transferring the vertical chords of Fig. 5 to a new diagram in which the chords near the vortex k are much farther apart than in the original figure. Figs. 2 and 4 were not, however, obtained by first constructing Fig. 5 and then constructing from it the horizontally distorted figure, but the ordinates of the curve were obtained, as stated above, by calculation, thus avoiding the errors to which all graphical methods are liable.

A curve like that given in Fig. 4 may easily be constructed from the calculated ordinates, particularly if it is placed upon finely lined section paper; and if the curve be constructed on such a scale that the greatest chord $BC = 20$ inches, the results obtainable from it will be sufficiently accurate for all the cases that arise in practice.

French and American Patents. — Laboulaye considers the French people as dupes of the great name of Liberty, and recommends to the consideration of French inventors the example of America. He says that "all nations which do not understand and adopt the American laws are destined to see their industry declining before that of America." The multitude of detailed inventions which have been accumulated in that country, and which are daily continuing to accumulate, in the way of sewing machines, reapers, fire-arms, etc., furnishes sufficient demonstration of the truth of this statement.—*Soc. d'Encour. pour l'Ind. Nat.* C.

EXPERIMENTS WITH THE STEAM-CUTTER OF THE UNITED STATES STEAMSHIP "PENSACOLA."

By Chief Engineer Isherwood, U. S. Navy.

The experiments described in this article were made with the steam-cutter of the United States steamship *Pensacola* by the writer during the time he was Chief Engineer of the Mare Island Navy Yard, California.

The principal object of the experiments was to ascertain the law of the variation of the resistance of the hull in function of its speed; incidental to which there was obtained the maximum power which the machinery could develop, and the corresponding speed of the vessel.

Before proceeding to the experimental data and to the analysis of their results in the cases of the different experimental speeds, there must be given the dimensions, proportions, etc., of the hull and of its machinery, and a description of the manner in which the data were obtained and the results deduced.

The cutter was an open boat constructed at the Mare Island Navy Yard of wood, and sheathed with copper.

Hull.

Extreme length, . . .		38 feet 1 inch.
Length from forward edge of rabbet of stem to after side of sternpost, on load water-line, ...		35 feet.
Extreme breadth on load water-line,		8 feet 11 inches.
Depth from lower edge of rabbet of keel to top of gunwale at middle of length,		4 feet 3½ inches.
Depth from lower edge of rabbet of keel to load water-line,	Forward,	1·600 feet.
	Mean,	2·175 feet.
	Aft,	2·750 feet.
Depth of keel below the lower edge of its rabbet,	Forward,	0·400 foot.
	Mean,	0·575 foot.
	Aft,	0·750 foot.
Draught of water to load water-line,	Forward,	2 feet.
	Mean,	2 feet 9 inches.
	Aft,	3 feet 6 inches.

Area of greatest immersed transverse section to load water-line,	12·53 square feet.
Area of load water-line,	207·62 square feet.
Area of the immersed external surface of the hull to load water-line,	332·85 square feet.
Displacement to load water-line,	269·00 cubic feet.
Displacement to load water-line,	7·700 tons.
Displacement per inch of draught at load water-line,	0·4953 ton.
Ratio of the area of the greatest immersed transverse section to the area of the circircumscribing parallelogram,	0·6461.
Ratio of the area of the load water-line to the area of the circumscribing parallelogram,	0·6653
Ratio of the displacement to the circumscribing parallelopipedon,	0·3963
Ratio of the length to the breadth on the load water-line,	3·9252
Angle of dead-rise at the greatest immersed transverse section,	22½ degrees.
Weight of the hull and its fittings,	6,270 pounds.

ENGINES.

There are two vertical, direct-acting, non-condensing engines, one placed immediately behind the other, with the axes of the cylinders in the same vertical plane with the axis of the shaft. Each cylinder has a three-ported slide valve, unbalanced, and worked direct from the shaft by means of an eccentric and its rod. The valve of the forward cylinder is upon its after side, and of the after cylinder, upon its forward side. The starting and reversing are effected by turning the eccentrics to stops upon the shaft, by means of a mitre-gear and hand-wheel at the centre of the engines. Both cylinders are bolted to a horizontal flat plate of cast iron that forms their bottoms and is supported upon four cast iron standards which are bolted in turn to a bed-plate secured to the hull—two standards at each end of the bed-plate. The inner sides of each pair of standards are formed into guides for the crosshead. There are but two main pillow-blocks, and they are bolted to, and supported upon, the bed-plate. The forward crank-pin is overhung. There is one plunger feed-pump, vertical, at the forward end of the bed-plate and supported upon it. This pump is worked direct from a pin in the crosshead of the forward engine. The distance between the axes of the cylinders is 22 inches. The cylinders and their valve-chests are without covering of any kind. The eccentrics are between the engines, and each one is directly below the valve-stem to which its rod is attached. The exhaust steam is delivered into the chimney of the boiler and forms an artificial draught. There is a heater for the feed-water which is heated by the exhaust steam to about 75 degrees Fahrenheit above the temperature of the sea-water whence it is taken.

The following are the principal dimensions:

Number of cylinders,	2·
Diameter of cylinders,	6 inches.
Diameter of piston-rods,	$1\frac{1}{8}$ inches.
Stroke of pistons,	6 inches.
Area of both pistons, exclusive of area of piston-rods,	55.554 square inches.
Space displacement of both pistons per stroke,	0·1919 cubic foot.
Breadth of steam-port,	$\frac{5}{8}$ inch
Length of steam-port,	4 inches.
Area of steam-port,	2·5 square inches.
Breadth of exhaust-port,	$\frac{7}{8}$ inch.
Length of exhaust-port,	4 inches.
Area of exhaust-port,	3·5 square inches.
Diameter of connecting-rods in necks,	$1\frac{3}{16}$ inches.
Length of connecting-rods between centres,	1 foot $2\frac{13}{16}$ inches.
Diameter of crosshead journal,	$\frac{7}{8}$ inch.
Length of crosshead journal,	$1\frac{1}{2}$ inches.
Diameter of crankpin journal of after engine,	2 inches.
Length of crankpin journal of after engine,	$2\frac{1}{2}$ inches.
Diameter of crankpin journal of forward engine,	$1\frac{3}{8}$ inches.
Length of crankpin journal of forward engine,	2 inches.
Diameter of main journals,	$2\frac{1}{2}$ inches.
Length of main journals,	$2\frac{1}{2}$ inches.
Width of eccentric straps,	1 inch.
Diameter of eccentric rods,	$\frac{7}{8}$ inch.
Diameter of feed-pump (single acting and for both engines),	$1\frac{1}{4}$ inch.
Stroke of feed-pump plunger,	6 inches.

Diameter of valves (poppets) of feed pump, .	1 inch.
Number of thrust collars, . .	5.
Inside diameter of thrust collars, . . .	2½ inches.
Outside diameter of thrust collars, . .	3⅜ inches.
Width of thrust collars, ...	½ inch.
Length of crosshead guide-gibs, . .	3 inches.
Breadth of crosshead guide-gibs, . . .	2 inches.
Thickness of side of cylinders, . . .	⅝ inch.
Thickness of plate to which cylinders are bolted,	$1\frac{3}{16}$ inches.
Thickness of bed-plate, ...	1¼ inches.
Length occupied by the engines in the forward and aft direction of the vessel, . . .	3 feet 6¼ inches.
Breadth occupied by the engines in the athwartship direction of the vessel, . .	2 feet 3⅝ inches.
Height of the engines above the bottom of the bed-plate, ...	3 feet 6 inches.

BOILER.

There is one boiler of the locomotive type, with iron tubes in direct continuation from the furnace to the chimney.

The front portion of the boiler is rectangular in plan with a semi-cylindrical top. The length of this portion is 2 feet 10 inches; breadth, 3 feet 6 inches, and height, 4 feet. Upon its top, at its centre, is a cylindrical steam-chest, 18 inches in diameter and 18 inches high. This front portion contains the furnace, 2 feet 3 inches long, 3 feet wide and 2 feet high above the top of the grate. The furnace top is horizontal; the grate is horizontal, and is fired from two doors, one in each side of the front portion of the boiler. The openings for these doors are rectangular, 12 inches wide and 8½ inches high. The bottom of the grate is on the level of the bottom of the front portion of the boiler, and the ash-pit is of cast iron, placed 6 inches below the bottom of the grate.

The remaining portion of the boiler is cylindrical, 3 feet 1 inch in diameter, and 4 feet 4 inches in length, 10 inches of which form the back smoke-box, on the top of which the chimney is placed.

The tubes are eighty-two in number, 2 inches in external diameter, 1¾ inches in internal diameter, and 44½ inches in length between tube plates. The least water space between the tubes is ¾ inch.

The boiler and steam-pipe are covered with thick felt.

The following are the principal dimensions and proportions of the boiler:

Extreme length,	7 feet 2 inches.
Extreme breadth,	3 feet 6 inches.
Extreme height, exclusive of steam-drum,	4 feet.
Extreme height, inclusive of steam-drum,	5 feet 6 inches.
Number of furnaces,	1.
Length of grate-bars,	2 feet 3 inches.
Breadth of grate,	3 feet.
Area of grate surface,	6·75 square feet.
Number of tubes,	82.
Outside diameter of tubes,	2 inches.
Inside diameter of tubes,	1¾ inches.
Length of tubes between tube-plates,	3 feet 8½ inches.
Water-heating surface in the furnace,	24·75 square feet.
Water-heating surface in the tubes, calculated for inside diameter,	139·29 square feet.
Water-heating surface in the back tube-plate, to 3 inches above furnace top,	4·16 square feet.
Total water-heating surface,	168·20 square feet
Steam superheating surface in the back tube-plate, above 3 inches above furnace top,	1·93 square feet.
Diameter of chimney,	9½ inches.
Height of chimney above the level of the grate,	11 feet.
Aggregate cross area of the tubes,	1·3700 square feet.
Cross area of the chimney,	0·4922 square foot.
Water space to 3 inches above furnace top,	21·563 cubic feet.
Steam space above 3 inches above furnace top, in boiler proper,	17·723 cubic feet.
Steam space in the steam-drum,	2·650 cubic feet.
Total steam space above 3 inches above furnace top,	20·373 cubic feet.
Ratio of the water-heating to the grate surface,	24·9185 to 1·0000.
Ratio of the steam superheating to the grate surface,	0·2859 to 1·0000.
Ratio of the grate surface to the cross area of the tubes,	4·9270 to 1·0000.
Ratio of the grate surface to the cross area of the chimney,	13·7139 to 1·0000.
Diameter of the blast-pipe (one orifice at base of chimney),	1⅛ inches.

SCREW.

There is one brass screw. The forward and after edges of its blades, viewed in projection on a plane parallel to its axis, are parallel to each other and perpendicular to the axis.

The thickness of the blades, just above the fillet joining them to the hub, is $\frac{13}{16}$ inch.

The following are the principal dimensions:

Diameter of the screw, . . .	3 feet.
Diameter of the hub, ...	4 inches.
Pitch (uniform), ...	5 feet 4 inches.
Number of blades, ...	3.
Length of the blade on a line parallel to the axis,	0·8889 foot.
Fraction used of the pitch, . .	0·5000.
Helicoidal area of the blades, . . .	4·8910 square feet.
Projected area of the blades on a plane at right angles to axis, . . .	3·4904 square feet.

WEIGHTS OF THE MACHINERY.

	Pounds.
Weight of engines, ...	1460
Weight of line shaft, ...	195
Weight of stern stuffing box, . . .	46
Weight of stern bearing, ...	21
Weight of screw, ...	140
Weight of boiler, ...	4515
Weight of cast iron ash pan under boiler, .	253
Weight of boiler chimney and sundry pipes, .	210
Total weight of metal in machinery,	6840
Weight of water in boiler, . . .	1342
Weight of felting, paint, etc., . . .	48
Total weight of machinery, . .	8230

EXPERIMENTS MADE AT THE MARE ISLAND NAVY YARD, CALIFORNIA, WITH THE STEAM-CUTTER OF THE U. S. STEAMSHIP "PENSACOLA."

The steam-cutter of the United States steamship *Pensacola*, having been thoroughly repaired—hull and machinery—a set of experiments was made with it at the Mare Island Navy Yard, at different speeds, but with the same draught of water and trim, to ascertain its resistance at those speeds, the slips of the screw, and the indicated horsespower developed by the engines. These experiments were made during the month of December, 1870.

The base for the experiments, or the course passed over by the cutter during each run, was a straight line 8·955 feet long, as given by the very accurate survey of Mare Island. It extended from the northern side of the dry dock dolphins, or guard piers, to the northern side of the magazine wharf. This base was close under the lee of the high ground of the island. There was no breeze during the experiments, and the water was perfectly smooth. The velocity of the tide varied from nil to three geographical miles per hour.

Seven experiments were made at the speeds, respectively, of 6½, 6¾, 7, 7¼, 7½, 7¾ and 8 geographical miles per hour, as nearly as could be obtained. Each experiment consisted of six runs over the base, three in each direction, and the time of making them was selected when the tide had but little influence. The vessel's speed through the water, during each double run, was ascertained from the time of passing the ranging marks at the ends of the base.

Two indicators were used; one of them was kept permanently in position on one cylinder, and the other on the other cylinder, during the experiments. Each indicator communicated with both ends of its cylinder, and before use was put in perfect adjustment and had its spring tested.

A counter was attached to the screw-shaft, and registered the number of its revolutions.

In making the experiments, the cutter, at the intended speed, was brought opposite one end of the base and then run uniformly to the other, being kept in a straight line by an expert steersman. After passing the last end of the base a sufficient distance, the vessel was turned and the run repeated back in the same manner. The throttle-valve was always carried wide open during the turnings, as well as during the runs, and the steam pressure varied but slightly throughout an experiment, the supply of steam required being always within the capacity of the boiler to furnish, except at the speed of eight geographical miles per hour, which it was very difficult to maintain for even a single run.

From the commencement of each run to its end indicator diagrams were taken as rapidly as possible from each end of each cylinder. The steam pressure in the boiler, as given by a spring gauge, was noted at the end of every minute.

An observer, stationed always at the same part of the vessel, gave the signal the instant he was opposite the ranges at the ends of the base; and, at the same moment, two other observers took, one the time to a second, and the other the number on the counter. Thus the time of making each run, and the number of revolutions made by the screw in that time, were exactly ascertained.

The results of the experiments will be found in the following table, in which, for convenience of reference, the quantities have been grouped and the lines containing them numbered. For the same reason, the columns containing the quantities for the different speeds have been lettered.

EXPLANATION OF THE TABLE.

After the experiments were concluded, and the mean pressure ascertained for each double run from the indicator diagrams taken during that run, a straight base line was divided into abscissæ representing the experimental speeds. From the end of each speed abscissæ an ordinate was erected at a right angle to the base, and on it was laid off, by scale, the indicated pressure belonging to that speed. A fair curve was then passed among the ends of those ordinates, leaving as many on one side as on the other. Again, the slips of the screw having been calculated for each experimental speed, were laid off on the same ordinates, and a fair curve passed among the ends of the ordinates in the same manner as before, leaving as many ends on the one side of the curve as on the other side. From these curves, and for the speeds given on line 1 of the following table, commencing at 6½ geographical miles per hour and increasing by one-quarter of a mile up to 8 miles per hour, there were taken off, by scale, the quantities on lines 2 and line 5 of the table, being, respectively, the slip of the screw in per centum of its axial speed, and the mean gross effective or indicated pressure on the pistons in pounds per square inch, according to the indicator diagrams. Line 3 contains the thrust of the screw, calculated from the quantities on lines 10 and 11, in the manner hereinafter shown under the head of Distribution of the Power. Line 4 contains the number of double strokes made by the engines' pistons per minute, and of revolutions made by the screw in the same time.

They were calculated from the pitch of the screw and the quantities on lines 1 and 2.

Distribution of the Indicated Pressure on the Piston.—Lines 5 to 11, both inclusive, give (line 5) the mean gross effective or indicated pressure on the piston in pounds per square inch for the different experiments, and the remaining lines contain the distribution of that pressure.

Line 6 gives the pressure required to work the engines and shafting—*per se*—when the screw is removed. It was obtained by direct trial.

Line 7 contains the net pressure applied to the shaft, in pounds per square inch of piston. It is the remainder of the pressure on line 5 after deducting that on line 6.

Line 8 contains the pressure absorbed by the friction of the load, in pounds per square inch of piston. It is 7½ per centum of the pressure on line 7.

Line 9 contains the pressure, per square inch of piston, expended in overcoming the resistance of the water to the surface of the screw blades. It is calculated from the quantity on line 16.

Line 10 contains the pressure, per square inch of piston, expended in the slip of the screw. It is calculated from the quantity on line 17.

Line 11 contains the pressure, per square inch of piston, expended in propelling the vessel. It is the pressure which remains after deducting from the pressure on line 7 the pressures on lines 8, 9 and 10.

Distribution of the Engine Power. — Lines 12 to 22, both inclusive, contain the gross-effective horses-power (line 12) developed by the engines, and their distribution. Lines 13 to 18, both inclusive, show the distribution of the power *absolutely*, that is, in horses-power; while lines 19 to 22, both inclusive, show this distribution in per centum of the net horses-power (line 14) applied to the shaft.

The distribution of the indicated or gross-effective horses-power developed by the engines has been calculated in the manner shown below under the head of Distribution of the Power.

The quantities on lines 19, 20, 21 and 22 are the per centum which the quantities on lines 15, 16, 17 and 18 are respectively of the quantity on line 14.

EXPERIMENTS WITH THE STEAM-CUTTER OF THE UNITED STATES STEAMSHIP "PENSACOLA."

By Chief Engineer ISHERWOOD, U. S. Navy.

Table containing the Results of the Experiments made with the Steam-Cutter of the United States Steamship "Pensacola," at the Mare Island Navy Yard, California, in December, 1870.

No. of Line.				a	b	c	d	e	f	g
1			Speed of the vessel per hour, in geographical miles of 6086 feet, ...	6·50	6·75	7·00	7·25	7·50	7·75	8·00
2			Slip of the screw, in per centum of its speed, ...	21·450	23·038	24·802	26·833	28·761	30·649	34·248
3			Thrust of the screw, in pounds, calculated from the piston pressure on lines 10 and 11, .	272·859	314·348	364·516	427·914	497·109	574·166	650·413
4			Double strokes of Engines' pistons, and revolutions of the screw, made per minute,	157·3792	166·8047	177·0392	188·4532	200·2290	212·5335	224·5679
5	DISTRIBUTION OF THE INDICATED PRESSURE ON THE PISTONS.		Mean gross-effective or indicated pressure on the pistons, in pounds per square inch, .	34·0000	38·7578	44·4897	51·6866	59·5470	68·2997	76·9957
6			Pressure required to work the engine, *per se*, in pounds per square inch of pistons, .	2·0000	2·0000	2·0000	2·0000	2·0000	2·0000	2·0000
7			Net pressure applied to the shaft, in pounds per square inch of pistons, . . .	32·0000	36·7578	42·4897	49·6866	57·5470	66·2997	74·9957
8			Pressure absorbed by the friction of the load, in pounds per square inch of pistons, .	2·4000	2·7568	3·1867	3·7265	4·3160	4·9725	5·6247
9			Pressure expended in overcoming the resistance of the water to the surface of the screw blades, in pounds per square inch of pistons, ...	3·4048	3·8228	4·3085	4·8792	5·5072	6·2057	6·9296
10			Pressure expended in the slip of the screw, in pounds per square inch of pistons, .	5·6192	6·9509	8·6806	11·0255	13·7250	16·8932	20·1363
11			Pressure expended in the propulsion of the vessel, in pounds per square inch of pistons,	20·5760	23·2273	26·3139	30·0554	33·9988	38·2283	42·3051
12	DISTRIBUTION OF THE ENGINE POWER.	ABSOLUTE.	Gross-effective or indicated horses-power developed by the engines, ...	9·0080	10·8835	13·2596	16·3977	20·0719	24·4370	29·1082
13			Horses-power expended in working the engines, *per se*, ...	0·5299	0·5616	0·5961	0·6345	0·6741	0·7156	0·7561
14			Net horses-power applied to the shaft, ...	8·4781	10·3219	12·6635	15·7632	19·3978	23·7214	28·3521
15			Horses-power absorbed by the friction of the lead, ...	0·6359	0·7741	0·9498	1·1822	1·4548	1·7791	2·1264
16			Horses-power expended in overcoming the resistance of the water to the surface of the screw blades, ...	0·9018	1·0737	1·2837	1·5484	1·8571	2·2209	2·6200
17			Horses-power expended in the slip of the screw, ...	1·4887	1·9523	2·5868	3·4970	4·6265	6·0444	7·6124
18			Horses-power expended in the propulsion of the vessel, ...	5·4517	6·5218	7·8432	9·5356	11·4594	13 6770	15·9933
19		PROPORTIONAL.	Per centum of the net power applied to the shaft, absorbed by the friction of the load, .	7·50	5·50	7·50	7·50	7·50	7·50	7·50
20			Per centum of the net power applied to the shaft, expended in overcoming the resistance of the water to the surface of the screw blades, ...	10·64	10·40	10·14	9·82	9·57	9·36	9·24
21			Per centum of the net power applied to the shaft, expended in the slip of the screw, .	17·56	18·91	20·43	22·19	23·85	25·48	26·85
22			Per centum of the net power applied to the shaft, expended in the propulsion of the vessel, ...	64·30	63·19	61·93	60·49	59·08	57·66	56 41

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MANNER OF CALCULATING THE DISTRIBUTION OF THE POWER DURING THE EXPERIMENTS.

To illustrate the manner of calculating the distribution of the indicated or gross-effective horses-power developed by the engines during the experiments, the following detail is given for the experiment in column **a** of the table.

The pressure required to work the engines and shafting, *per se*, being taken at 2 pounds per square inch of pistons, there is thus absorbed (line 13) 0·5299 horse-power.

Deducting from the gross-effective power (line 12) of 9·0080 horses developed by the engines this power of 0·5299 horse, there remains (line 14) the net power of 8·4781 horses applied to the shaft, of which 7½ per centum or 0·6359 horse (line 15) is absorbed by the friction of the load.

The power expended in overcoming the resistance of the water to the surface of the screw blades (line 16), that is, in overcoming their skin resistance, calculated in the ratio of the square of the velocity, and for a value of 0·45 pound per square foot of helicoidal surface moving in its helical path with a velocity of 10 feet per second, amounts to 0·9018 horse.

The powers (0·6359 and 0·9018 horse) absorbed by the friction of the load and expended in overcoming the resistance of the water to the surface of the screw blades being deducted from the net power (8·4781 horses) applied to the shaft, there remain 6·9404 horses-power expended in the slip of the screw and in the propulsion of the hull. And, as the slip of the screw (line 2) is 21·45 per centum of its axial speed, the power expended in it is (6·9404×0·2145=) 1·4887 horses (line 17) leaving (6·9404—1·4887=) 5·4517 horses (line 18) expended in the propulsion of the simple hull.

Collecting the foregoing, we have the following distribution of the power, namely:

	Horses-power.	Per cent.
Gross-effective or indicated power developed by the engines, ...	9·0080	
Power required to work the engines and shafting, *per se*, ...	0·5299	
Net power applied to the shaft, . .	8·4781 or	100·00

Power absorbed by the friction of the load, .	0·6359	or	7·50
Power expended in overcoming the resistance of the water to the surface of the screw blades, .	0·9018	"	10·64
Power expended in the slip of the screw, .	1·4887	"	17·56
Power expended in the propulsion of the vessel, .	1·5717	"	64·30
Totals, . . .	8·4781	or	100·00

Thrust of the Screw.

The thrust of the screw during the foregoing performance can be calculated from the piston pressures on lines 10 and 11, the sum of which reduced in the ratio of the length (one foot) of the double stroke of the pistons to the pitch ($5\frac{1}{3}$ feet) of the screw, and multiplied by the aggregate number of square inches in the two pistons, will give the thrust of the screw in pounds; or, what is the same, the statical resistance of the vessel in pounds at the experimental speed.

In the case of experiment **a**, the sum of the piston pressures on lines 10 and 11 is 26·1952 pounds per square inch, and, as the aggregate area of the two pistons is 55·554 square inches, the thrust of the screw, or resistance of the vessel, is $\left(\frac{26{\cdot}1952}{5\frac{1}{3}} \times 55{\cdot}554 =\right)$ 272·859 pounds (line 2).

Results of the Experiments.

The mean steam pressure in the boiler during the experiment recorded in column **a** of the preceding table was 50·42 pounds per square inch above the atmosphere; during the experiment recorded in column **b**, 57 pounds; during the experiment recorded in column **c**, 64 pounds; during the experiment recorded in column **d**, 72 pounds; during the experiment recorded in column **e**, 79·75 pounds; during the experiment recorded in column **f**, 87 pounds; and during the experiment recorded in column **g**, 94 pounds.

§ The temperature of the feed-water before entering the heater was 55 degrees Fahrenheit; and when entering the boiler, 130 degrees Fahrenheit.

§ The resistances of the hull at different speeds varied in a much higher ratio than the square of the speed, as will be seen by the following comparison, in which they are given both proportionally for the square of the speed, and also proportionally as ascertained by experiment and deduced from the quantities on line 3 of the preceding table.

Column of the table.	Speeds of the vessel in geographical miles per hour.	Squares of the speeds, proportionally.	Experimental resistances, proportionally.
a	6·50	1·0000	1·0000
b	6·75	1·0785	1·1525
c	7·00	1·1599	1·3359
d	7·25	1·2440	1·5683
e	7·50	1·3311	1·8219
f	7·75	1·4216	2·1043
g	8·00	1·5147	2·3837

The power of the speed of the vessel, in which its resistances increased from 6·50 geographical miles per hour to each of the experimental speeds, is as follows:

Speed of the vessel in geographical miles per hour.	Power of the speed in which the vessel's resistances increased.
6·50	——
6·75	3·7571
7·00	3·9090
7·25	4·1203
7·50	4·1906
7·75	4·2300
8·00	4·1829

The power of the speed of the vessel, in which its resistances increased for each experimental increment of speed of one-fourth of a geographical mile per hour, is as follows:

Speed of the vessel in geographical miles per hour.	Power of the speed in which the vessel's resistances increased from one experimental speed to the next greater.
6·50 6·75	3·7571
6·75 7·00	4·0756
7·00 7·25	4·5708
7·25 7·50	4·4190
7·50 7·75	4·3990
7·75 8·00	3·9225

According to the above, the power of the speed in which the vessel's resistance gradually increased from one experimental speed to the next greater, gradually rose until it became a maximum at the speed of 7·25 geographical miles per hour, from which to the speed of 8·00 geographical miles per hour it gradually declined.

During the different experiments the trim of the vessel changed with each change of speed, and in a very marked manner; the bow rising and the stern falling with each increase of speed. Notwithstanding the sharpness of the bow, the vessel, even at her lowest speed, carried a wide and high wave before her.

At the lowest speed there was a hollow or marked depression in the water a little abaft the stern, followed immediately by a corresponding wave or elevation of water above the general level, and with each increase of speed this hollow became deeper and deeper, and farther and farther from the stern, while the wave which followed it became higher and higher, and also more and more distant. At the highest speed the gunwale at the stern of the cutter was below the general level of the water, so that the persons sitting in the stern sheets appeared to an observer on shore to be standing waist-deep in the water, the cutter's stern being invisible.

There was not only this great alteration of the vessel's trim observed, but also that she began at medium speed to rise bodily above her mean draught of water when at rest, the bow becoming disproportionately high out of water.

The above phenomena, no doubt, exist for all vessels, be their size and form what they may, when their speed exceeds the limit at which their resistances increase in the ratio of the squares of the speeds; but this limit being farther and farther removed as the hull has greater length and finer form, is not in large and well-modeled vessels reached with the ordinary speeds of practice; but when even such vessels are driven beyond the speed of about 12 geographical miles per hour the appearances described make their influence felt.

The first cause of this marked change of trim with the increasing speeds of the cutter was the shortness of her after body comparably with her draught of water aft. Now, the water replacing at the vessel's after body that which was displaced at her fore body, comes from the plane of greatest pressure, which is the plane passing horizontally through the lower edge of the rabbet of the keel, and it rises solely by the force of gravity, the weight of the adjoining column of water measured from the plane referred to up to the water level, forcing it upwards, and it rises with the same velocity no matter what may be the vessel's speed. But, as the vessel's speed increases, the ascending mass of water cannot reach the after body in time to support it in the position it had when at rest, and, consequently, this after body must drop until it does meet the ascending mass of water, and obtains thereby sufficient floatation. The greater the speed of the vessel, the farther the after body must drop, and with each dropping the resistance of the vessel must increase. As long, however, as the speed of the vessel is such, relatively to her length of after body and draught of water aft, that the ascending mass of water can reach the after body in time, there will be no dropping at the stern, and the vessel's resistance up to that speed will be in the ratio of the squares of the speeds.

The phenomena, as regards the bow, are influenced by the length of the fore body relatively to the speed. The displaced water rises vertically (that being its line of least resistance) along the sides of the fore body, and spreads out over the general level, the height of the rise and the area for the spreading out being measured, other things equal, by the length of the side of the fore body. When the speed of the vessel is increased to such a degree that the wave of translation does not move swiftly enough to keep out of the way of the vessel, the latter rises upon it as upon an inclined plane, and emerges bodily above her mean draught of water when at rest, thus offering a less external wetted surface and a less greatest immersed transverse section to be driven by the engines. In this way the decreased power of the speed in which the resistance of the vessel increased at the higher rates of speed may be explained.

The resistance of the hull is composed of two parts ; one, that of her external immersed or wetted surface ; the other, that of her form abstracted from this surface resistance. The first may be called her resistance in function of surface, and the last her resistance in function of form. The first may be approximated with reasonable accuracy by calculation ; the last must be ascertained experimentally.

The experiments with the *Pensacola's* steam-cutter allow this separation of these two resistances to be made in her case, and each to be ascertained for the different experimental speeds of the vessel.

The speed with which the watery molecules glide over the wetted surface of the hull is less than the speed of the vessel, owing to the inclination of her lines to her longitudinal axis, and, in the case under examination, these two speeds may be taken to be in the ratio of 0·974 to 1·000. Assuming the wetted surface not to change in area during the experiments, it is 332·85 square feet, each square foot of which, when moving with the velocity of 10 feet per second, has the resistance of 0·45 pound, which resistance increases and decreases with the square of the velocity. Calculating with these data the resistance of the external immersed or wetted surface of the hull for each experimental speed, and deducting it from the resistance of the hull at each of these speeds (line 3 of the table), the remainder will be the resistance in function of form. And it is evident that, as the resistance in function of surface varies with the square of the vessel's speed, all the increased resistance above that ratio must be due to the form alone.

In the following table will be found the results of these calculations, the resistance of the vessel in function of surface and in function of form being given separately :

Speed of the vessel in geographical miles per hour.	Total resistance of the vessel in pounds.	Resistance of the vessel in function of surface alone, in pounds.	Resistance of the vessel in function of form alone, in pounds.	Per centum which the resistance of the vessel in function of surface is of her total resistance.	Per centum which the resistance of the vessel in function of form is of her total resistance.
6·50	272·859	171·484	101·375	62·85	37·15
6·75	314·348	184·965	129·383	58·84	41·16
7·00	364·516	198·445	166·071	54·44	45·56
7·25	427·914	213·590	214·324	49·91	50·09
7·50	497·109	228·402	268·707	45·95	54·05
7·75	574·166	243·846	330·320	42·47	57·53
8·00	650·413	259·723	390·690	39·93	60·07

The power of the speed of the vessel in which its resistances in function of form alone increased for each experimental increment of speed of one-fourth of a geographical mile per hour, is as follows:

Speed of the vessel in geographical miles per hour.	Power of the speed in which the vessel's resistances in function of form alone increased from one experimental speed to the next greater.
6·50 6·75	6·4745
6·75 7·00	6·8719
7·00 7·25	7·2727
7·25 7·50	6·6660
7·50 7·75	6·3047
7·75 8·00	5·2812

The quantities on line 22 of the table show the proportion of the net horse-power developed by the engines applied to the screw shaft, which was utilized in the propulsion of the vessel. They consequently represent the relative economic efficieny of the screw, referred to the net horse-power. at the different speeds of vessel. Had the resistances of the vessel been in the ratio of the squares of its speeds, the quantities on line 22 would have been equal; the decrease of the screw's efficiency with the increase of the vessel's speed, is due to the fact that the resistance of the vessel increased in a higher ratio than the square of its speed, while the resistance of the watery fulcrum to the screw blades increased only in the ratio of the square of the number of their revolutions in equal time, and that the number of these revolutions, *cæteris paribus*, is in the direct ratio of the speed of the vessel; that is to say, if the resistance of the vessel is as the square of its speed, the number of revolutions of the screw in equal time will be as the speed of the vessel.

As the resistance which the screw experiences from its watery fulcrum. other things equal, is as the square of the number of its revolutions in a given time, and as the vessel's speed is as the number of revolutions made by its screw in equal time, provided the resistance of the vessel increased as the square of its speed, then the resistances of the screw and of the vessel, in this case, would increase in the same duplicate ratio of the speed, and the slip of the screw would consequently remain constant, and its economic efficiency undergo no change.

But if the vessel's resistance increased in a higher ratio than the square of its speed, the resistance of the screw remaining in the ratio of the square of its revolutions in equal time, then the slip of the screw would increase with increased speed of vessel, and become greater and greater as that speed became greater and greater, and the screw would have, in consequence of these increasing slips, less and less economic efficiency.

The loss of economic efficiency by the screw, primarily caused by increased slip, includes not only the loss due to the increased slip, *per se*, but also that which is due to the increased resistance of the water to the screw surface, or, in other words, to the increased skin resistance of the blades, because, in order that the vessel make a given speed, more revolutions of the screw will be required in equal time with the increased slip of the screw, whose corresponding surface loss will be as the squares of the number of revolutions made in equal time.

Fall of a Market Roof in Paris.—On a cold night of last December, when the thermometer stood at −15° (5°F.), the metallic roof of St. Martin market suddenly fell. It was built upon rigid supports and seems to have been sufficiently strong. The cause of the fall was therefore a mystery, and the French engineers are discussing the subject with much interest. They very generally agree in regarding the rigidity of the supports as a defect and in thinking that the extremities of every beam should be allowed sufficient lateral play to prevent any injurious effect, either from contraction by cold or from expansion by heat.—*Chron. Indust.* C.

Temperature of Frozen Lakes.—F. A. Forel has made a series of observations on the Swiss lakes, similar to that of Buchanan at Loch Lomond. He finds that the limit of the superficial chill is much greater than has been hitherto supposed, extending in some cases even to the depth of 110 metres (120·3 yards). The penetration of the cold into the upper layers takes place very gradually and progressively. It does not appear to be accomplished either by convection or by mechanical mixture under the action of waves and currents, but may perhaps be connected with conductibility and radiation. Observations extended over an interval of forty days showed a great uniformity of temperature, but at no time was the uniformity complete throughout the whole depth of the lakes.—*Comptes Rendus.* C.

EYE-MEMORY.

A Lecture delivered before the Franklin Institute March 29th, 1880.

By Charles G. Leland.

There are few people who have ever reflected on the fact that every one has within him a faculty which, if properly developed, would completely change our system of education by increasing to an incredible degree our power of mental acquisition. This faculty I term Eye-memory. It has already been recognized by writers as Visual Representation, Imaginary Appearance and Volitionary Pseudopia, each term expressing the subject in a manner characteristic of its inventor.

We are all in the habit of hearing the utterances of other people during our waking hours, of reading books and catching sounds. But unless we deliberately set ourselves to work to get these utterances, ideas or sounds *by heart*, we only retain a vague general impression of them. Getting by heart, or "memorizing," is effected by concentrating or intensifying the attention and by frequent repetition. When this is extensively practiced in youth, the mental memory is thereby greatly strengthened or improved, while the thinking faculties are, by the same process, stimulated and disciplined. This is, in fact, the real aim of most early education. Only the vulgar and ignorant believe that the acquisition of knowledge and the learning certain definite quantities of mathematics, languages or history alone constitute an education. A wiser man knows that it is the training of the mental powers which forms the true result of culture.

Now just as the mind may be instructed and disciplined by mere *reading*, that is to say, indirectly taught by symbols called letters, so it may be directly supplied with facts or phenomena by eye-memory. This is the impressing by will on memory things which we have *seen*. Thus, for instance, if you close your eyes and try to recall the exact appearance of any object with which you have been familiar, you will find great difficulty in doing so. As a rule children possess this faculty to a much higher degree than grown people. But if you put the object before you and look at it frequently you will succeed in learning it, so as to be able to read it at will. The longer you study it with a determination to remember it, the more vividly will its color and general appearance come before you. It is possible, with practice, to develop this faculty so as to produce the most extraordinary results. The absent friend may be recalled at will, so that his form appears as clearly defined as in life, and by frequent exercise you may surround yourself with familiar or imagined scenes which appear like nature. This power may be extended to books. You have all heard of people who "cipher" from imagined visual numerals, and of others who had the power to recall sheet-music, and to play from the notes thus brought before the eye. I have read of a Scotch preacher who said that, while apparently preaching without notes, he was really reading from a manuscript which he saw mentally before him. He could see even the marks of punctuation. And this use of the faculty of visual representation occurred whenever he had written a sermon and read it carefully before going into the pulpit. I venture to believe that it would be possible, with practice, to recall any page of anything which we had read, or rather seen, and in like manner to get by eye a gallery of pictures. As it is, we may appreciate and thoroughly enjoy works of art. But unless we deliberately exert our will, and intentionally impress them on the memory with much trouble, they will not recur to us as real things. They will not come when we call to them. Why is it that, after going through a gallery, we remember a few pictures and forget others? Simply because we have unconsciously, through *interest*, brought our memory to bear upon the few. Had we been trained from childhood to use this visual memory in the same manner in which we are trained to exercise mental memory, we could probably recall at will any object which we had *once* willed to remember.

There have been, however, many persons who have acquired this desirable art. Thus we are told that Nicolas Loir, an eminent French painter and engraver, when in Italy, devoted his time to contemplating the works of the great masters, his eye-memory becoming so retentive by practice that he was able to sketch the pictures which had pleased him most.

I have met with a coachmaker, also a draughtsman, who, after seeing any vehicle pass by, however rapidly, can draw and color it in detail to the minutest ornaments, and who can do the same of any object which he saw even forty years ago, if he had taken pains at the time to learn it. I know a lady who, while in Europe, memorized many galleries of pictures and shop windows. Francis Galton has completely established the fact that there are in England hundreds of accountants who carry out sums in arithmetic entirely by visual representation. This power is popularly admired as a rare gift; in reality it is irrepressible in a few, involuntarily developed in others, and is innate in us all.

The importance of developing this faculty has suggested itself to many artists. Thus Couture advised his pupils to let the eye rest for an instant on passers-by in the street, and then attempt to draw them. I have seen this put in practice with perfect success, and have heard from others authentic experiences of it. The various stages of the process were extremely curious and interesting. At first only a hat, and perhaps the general appearance of an arm, or a leg, can be caught, but in a few hours the expression of the whole figure is seldom missed. No one who had not practiced this, or seen it done, would believe how rapidly the observation and memory are developed by this kind of "flash photograph" drawing, or what an air of vivacity and motion is imparted to the figures. I recommend the practice of it specially to those who intend to draw for the illustrated newspapers. They are often obliged to make notes or hasty sketches of moving masses of men, and they perforce acquire a certain degree of eye-memory. But we need only study the details of most of their pictures of crowds to see that it is not highly developed with them.

While collecting facts on eye-memory, I wrote to Dr. Oliver Wendell Holmes for information, and I need not say that I was not disappointed, as I received from him his work entitled *Mechanism in Thought and Morals*, in which I find that the subject of "pictured thought," as a branch of conscious mental action, has not escaped his attention. He has ingeniously illustrated it "by the panorama of their past lives, said by people who have escaped from drowning to have flashed before them." This actually happened to Dr. Holmes himself, as it did to my brother Henry Perry Leland. I also received from Dr. Holmes the work on Visions, by Dr. Edward H. Clarke, edited by himself. In this book that which the author calls "the power of the will to produce objective *pseudopia*," or to see that which is not before the eyes, is treated almost exhaustively, as regards the physical explanation of the faculty. "Sight," says Dr. Clarke, "is not a function of the eyes, but of the brain." "There is a way by which volition plays with its utmost energy upon the angular gyrus, or some other centre, and drives its machinery into action. If this can be accomplished, vision is accomplished. When we consider that there is no part of the body which cannot be affected somewhat by volition, it would be singular if the visual ganglia should be the only ones withdrawn from the influence and authority of the will." In illustration of the fact that the will can reproduce what the eye has seen, Dr. Clarke cites the case of a gentleman who, being fond of statuary, succeeded, after a few trials, in producing visions of statues, and even in imagining new ones. This author has, in my judgment, completely established the fact that every object making an impression on the brain, or visual apparatus, leaves an organic trace there, which may be reproduced at an indefinite period afterwards by cerebral action. I find in fact, in the *Visions* of Dr. Clarke, as in the *Mental Physiology* of Dr. William B. Carpenter, a sound basis for, and a perfect confirmation of, all that I claim as regards eye-memory.

Goethe tells us, in his work *Aus meinem Leben, Wahrheit und Dichtung*, that having one day seen ideally a picture by Van Ostade, he cultivated the faculty so as to afterwards produce at will subjective copies of pictures and works of art. De Quincey recognized and distinctly describes the faculty of recalling or creating visions at will. In fact, the illustrations that this power exists are so numerous, and the physiological explanations of it are so copious and satisfactory, that it would be impossible to bring them within the limits of the longest lecture. But I have not been able to ascertain that any writer has ever contemplated the deliberate cultivation of volitional vision as an aid to every branch of intellectual education and of art. I do not know that any one has contemplated the possibility of its being introduced into schools and taught in classes. I believe myself that entire books will be thus memorized with little effort, that all which the eye has seen the trained will will revive, and that, far beyond all this, imagination aided by volition, will evoke from the mystic brain cells, where they lie by millions upon million *perdu*, all manner of beautiful forms, and create from them at will others more beautiful. Would not this be a new life for every man and woman of culture? Would not, in such a life, much that is mean and much which now degrades us, vanish like mists before sunshine? Yet all this is just as physically possible as that sounds and sights should be transmitted by telegraph and preserved *ad infinitum*.

But to return to the application of eye-memory to art. When I was in St. Petersburg, Russia, I found that great attention was there paid, in the School of Design, to free-hand drawing. The happiest results were secured by telling the pupils to study a given object for ten minutes, and then; the object being removed, to draw it. Mr. John Sartain has told me that, in his youth, his teacher of drawing, the celebrated Varley, would place the image or picture to be copied in one room and tell the pupils to work in another, allowing them to go, from time to time, to look at it. I understand that the Russian method has been practiced in some schools in Philadelphia. It cannot be denied that when the model is always directly before the pupil the latter seldom observes anything carefully, nor does he study the relations of the details of form, light and shade and color as he would when memorizing. I have come to the conclusion that it requires full half an hour for most people to get by heart or eye the simplest object in the world—that is to say, a billiard ball, with all its lights and shadows. But when the artist is compelled to get the whole object actually by heart, he studies the relations of the different qualities or details, and develops in his mind higher and much more vigorous powers of observation. Thus trained, his eye sees more at the first glance, he becomes self-reliant, he does not depend on the thousand times repeated, half-observant, glance.

We have all heard of Blake, the artist, who saw spectral delusions, or imaginary phantoms, so vividly that he used to copy them. Once, when he was thus painting Charles the First, as he believed, from life, for a friend, he stopped in his work. "Why do you not go on?" asked his friend. "Because William the Conqueror has just stepped in the way, and before him," answered Blake, very seriously. I will tell you a story upon this story, out of my own experience. Once, in London, after a dinner party, I was in our host's library, with a French gentleman, one of the guests. Finding that he was evidently well informed in art matters, and as there were several volumes of Blake's pictures on the table, I showed them to him. He had never seen anything of Blake's before, so I told him what I could remember of that extraordinary man, and how he used to paint from spectral delusions. "But he must have been mad," said the French gentleman. "Not at all," I replied; "he was almost a genius—*enfin monsieur, c'était un Doré manqué*—he was almost a Doré." The point of this remark was not apparent to me till some time afterwards, when I learned, to my astonishment, that it was to Monsieur Doré himself that I had addressed it!

Monsieur Doré is an artist of wonderful invention and of great fertility, but I know of none in whom the public have perceived so precisely what his limits are. We know what he knows by heart, and what his eye-memory has mastered, and when he is drawing on the old stock figures. Had he cultivated the faculty of visual memory in youth to perfection, he would have avoided such mannerism as we observe. For it evidently would fill the mind with facts or objects which would be in the highest degree suggestive and inspiring. We have all found in our own experiences that we remember certain scenes with great vividness when certain persons or certain pleasurable associations are connected with them. We remember the brow of the hill, the amber sunset sky, the foliage like dark bronze against it, because some young lady, perhaps, caused us to remember it. Our will was unconsciously exerted. This association of scenes with persons and events has become part of the stock-in-trade of the modern novelists. We all know how a certain scene was indelibly branded in the heroine's memory—how, to the end of her days, the ticking of the clock and the patterns in the carpet all rose up whenever anything recalled that awful hour. Yet there is a basis for curious or valuable observation in all this. We have in it a confirmation of my assertion that there are causes which will strengthen and develop to an unusual degree our memory of objects.

I have said that the power of memory by sight may be increased to a degree of which we have no conception, and also that young people, as De Quincey declares, possess this power more than those advanced in life. To prove this I will read to you a passage from the life of the celebrated French conjuror, Robert Houdin. It was this passage which first attracted my attention to eye-memory, and caused me to reflect on the indefinite degree to which it may be extended in education especially in that of artists. I must premise that this famous juggler had invented a trick, called Second Sight, which I saw performed by him and his son in Paris in 1848. He found that to effect this it was necessary to cultivate not merely his mental memory to an extraordinary extent, but to remember things as they *appeared*. The trick consisted effectively of getting by heart, or remembering, the exact appearance of every object which might by any possibility be brought by anybody to his exhibition. The son of Houdin, a boy, was blindfolded; the father, in another part of the hall, looked at the object, and his son promptly described it. There was, of course, a method of secretly signalling from one to the other; this is sometimes effected by a telegraphic wire in the floor, worked by the foot.

"I resolved," says Robert Houdin, "on making some experiments with my son Emile, and in order to make my young assistant understand the nature of the exercise we were going to learn I took a domino, the 4—5 for instance, and laid it before him. Instead of letting him count the points of the two numbers, I requested him to tell me the total at once.

"'Nine,' he said.

"Then I added another domino, the 4—3.

"'That makes sixteen,' he said without any hesitation.

"I stopped the first lesson here; the next day we succeeded in counting at a glance four dominoes; the day after, six: and thus at length we were enabled to give instantaneously the product of a dozen dominoes.

"This result obtained, we applied ourselves to a far more difficult task, over which we spent a month. My son and I passed rapidly before a toy-shop, or any other displaying a variety of wares, and cast an attentive glance upon it. A few steps further on we drew paper and pencil from our pockets, and tried which could describe the greatest number of objects seen in passing. I must own that my son far excelled me, for he would often write down forty objects, while I could scarcely recall thirty. Often feeling vexed at this defeat, I would return to the shop and verify his statement; but he rarely made a mistake.

"My male readers," continues Monsieur Houdin, "will certainly understand the possibility of this, but they will recognize the difficulty. As for my lady readers, I am convinced that they will see nothing remarkable in it, for they daily perform far more astounding feats. Thus, for instance, I can safely assert that one lady seeing another lady pass at full speed in a carriage, will have had time to analyze her toilette, from her bonnet to her shoes, and be able to describe not only the fashion and quality of the stuffs; but also say if the lace be real, or only machine-made. I have known ladies to do this. This natural or acquired faculty among ladies, but which my son and I had only gained by constant practice, was of great service in my performances; for, while I was executing my tricks, I could see everything that passed around me, and thus prepare to foil any difficulties presented me."

Having thus cultivated observation and memory, the juggler and his son proceeded to render themselves familiar with an incredible variety of small objects. Conjecturing, as the result afterwards proved, that they would have many curiosities or antiques, such as old coins, arms and jewelry, brought to them to describe, they visited many museums. It is very evident, not merely from Houdin's own account, but from what was practically shown in his public exhibitions, that in a few months the father and son added incredibly to their stores of knowledge or information, retaining a vivid picture of every object which they deliberately *willed* to remember. Having developed the eye-memory by hard work up to such a point that they could see a thing almost as clearly as if the original object, or indeed whole rows of such objects were present, they found that the faculty, once well acquired, kept itself in action with ordinary practice. They now learned very readily the characters or letters of many languages, such as Greek, Hebrew, Chinese, Russian and Turkish, the names of all surgical instruments, and of many other technical objects. Walking through a library, they could recollect the appearance of whole rows of books, with the titles on their backs.

There can be no question that Robert Houdin was an unusually clever man, of great powers of observation and quickness, which had been greatly improved by the practice of juggling. Yet, making every allowance for his remarkable talent, I am all the more convinced that his experiences and discoveries indicate that the faculty of an indefinite development of eye-memory exists in every one, especially in the young, and that it will at some future day enter largely into education, and form its physical basis. Anybody can verify for himself the simple fact that any object may be *eye-memorized* by special study. No casual observation, unaccompanied by the *will* to remember, will enable us to do so much as can be effected by determined effort. We may see a face a thousand times, and yet in most cases we cannot recall it so accurately for artistic purposes as if we had deliberately *studied* it a dozen times with that object. But it is especially to art students that I commend the practice of it. When you are copying an object, it makes a very great difference indeed whether you look very carefully at the original, and into its every condition, or merely *glance* at and set down what you half observe and *half* imagine. For it is a fact that in the most accurate copying we draw largely upon our imaginations. We are copying, let us say, a vase or a book, and, having secured a general conception of its proportions, we proceed by speculation or fancy more than we are ourselves aware of. As I have already said, when the model is *directly before* the pupil, he does not generally study it carefully as a whole, nor observe or memorize the proportions of its different parts. He copies it simply part by part. Now I would urge that the wonderful power of eye-memory, or of recalling objects exactly as they appear, should be deliberately cultivated, especially in the young. I think that by practicing as Robert Houdin practiced with his son, and by competing as they competed, very remarkable results would very soon be obtained. The pupils need not be taken about to shop windows; shelves and tables, at home, with objects arranged on them, would answer the purpose for primary lessons.

The next step, which goes beyond all that Robert Houdin conceived, just as it transcends the ordinary object-teaching of the Kindergarten, is the photographing some one object, as, for instance, a statue, so indelibly upon the eye and memory by the exercise of close observation, will, and renewal in the memory, that it can even serve as a visible model. In children who cannot draw, the faculty may be developed by examining them on maps and the relative boundaries of States. This is often done now, but when I was at school maps were indeed hung before the scholars, and we were required to learn them, yet it never entered into our teacher's head, or into our own, that the whole map might have been learned in less time by visual memory—by looking at and closing our eyes, and recalling at first the different colors of the different States, and then their relative position, and finally their shapes. The method by which this process of getting, for instance, a map, by eye, and even the peculiar processes by which different people will attempt it, are well described by Dr. Haslain (Sound Mind), who in turn is commented on by Dr. A. L. Wigan in his Duality of Mind (p. 313–14).

But it would be well if children could all draw, since drawing and memory are great mutual aids. I quite agree with Froebel, the Kindergarten philosopher, that it is highly important that a child should acquire some facility in drawing even before he learns to read and write, since the representation of actual things should precede the representation of signs and words. In connection with the subject of object-teaching and drawing, Emily Shirreff, the author of the *Intellectual Education of Women*, observes that "it would be curious to inquire how much of the loose thinking, the hazy perception of truth, which characterize the majority of even the educated portion of mankind, might be traced back to the absence of any *definite* impressions made in childhood in connection with the instructions given to them. Outside the school-room they acquire definite impressions, but they are acquired at random, and may be wholly wanting in accuracy."

(To be continued.)

ELECTRIC TIME TELEGRAPHS.

Read before the Franklin Institute at its meeting March 17th, 1880.

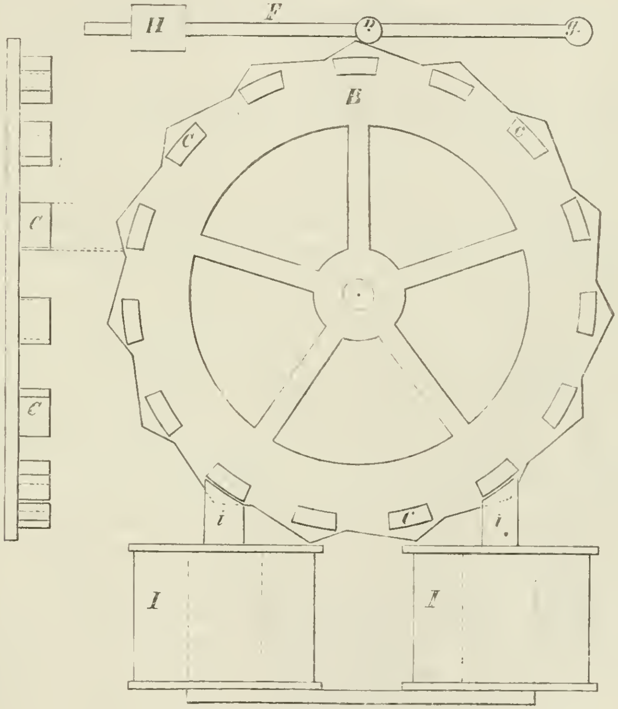
By Louis H. Spellier.

There are two classes of electric clocks the electric clock proper, or the electro-magnetic pendulum, and the electro-magnetic time telegraph. The former has been to this day more of a scientific curiosity than a useful invention. It is only the latter, the electric time telegraph, which has proved a partial success. As the name indicates, they are instruments which receive the time telegraphed. For this purpose a standard clock, which in certain intervals of time completes or breaks the circuit of a galvanic battery, is needed. Although many and various in construction, they all resemble each other very closely in their most essential parts.

They mainly depend upon the action of one electro-magnet and one armature. The latter is a piece of iron, which is attracted by the poles of the electro-magnet, when the telegraphing clock completes the circuit of a galvanic battery connected with it. As soon as the clock breaks the circuit again the armature is repelled to its former position by a spring or weight. This movement of the armature turns a wheel which drives time-indicating machinery, and is repeated as often as this machinery requires to indicate the time of the clock, which makes or breaks the electric circuit.

Such instruments work very well, if the action of the armature is needed about once every minute, but if repeated every second or two, then its imperfections become apparent. The movement of the armature is sudden and rapid. With a lightning-like velocity the armature moves toward the magnet, and is checked instantaneously in its rapid progress just at a time when nearest the magnet and most powerfully attracted. Naturally the wheel, which receives its moving impulse directly from the armature, moves with the same rapidity and is checked as suddenly. Those sudden checks, offered to the armature and wheel, show their damaging results in a comparatively short time, and soon impair the correctness of such instruments.

In correcting these destructive evils I never succeeded completely until an entirely new system suggested itself to me, and of which the accompanying figure shows the principle.



Instead of one armature I have a number of them, *C*, fastened at equal distances around the circumference of wheel *B*. With *B* on the same axle another wheel is fastened, having as many cogs, of the peculiar shape shown in the figure, as *B* has armatures. *F* is a lever with its oscillating centre at *g*, and has a pulley, *D*, which presses against the circumference of the wheel *B* by the weight *H*. *I i* is the electro-magnet. The electro-magnet is connected with a galvanic battery, of which the circuit is closed and opened by the oscillations of a pendulum. The instrument acts in the following manner:

When the current of the galvanic battery is closed, the armature C will be attracted by the electro-magnet, and move A and B in the direction indicated by the arrow, and stops as soon as C is directly over it. When in this position the pulley D rests upon the upper part of the cog, and presses against it. As soon as the electric current is disconnected, and the electro-magnet discharged of its magnetism, the pressure of the pulley D against the cog moves B in the direction indicated by the arrow, and stops moving when the pulley has reached the deepest point of the cog. This movement of B has brought the next armature, C, near to the magnet i. This armature will now be attracted at the next closing of the electric current. Then B will be moved again, and the cog will take the first position, and the pulley D presses upon it, ready to move the wheel as soon as the electro-magnet is again discharged of its magnetism; and so on, alternately, the electro-magnet and the pulley will interchange their action, and keep B revolving in the manner as the pendulum of the clock connects and disconnects the electric current.

The object in view, to avoid the sudden check to the armature, is hereby accomplished. No sudden check is offered to the armature, but when attracted it swings for a moment in short vibrations over the magnet before it comes to rest. It is comparatively noiseless in its movements, its sound being hardly perceptible. In this respect it is very much unlike other time telegraphs, whose clapping noise is their constant companion.

A time telegraph of this kind in operation at the monthly meeting of the Franklin Institute had, like the accompanying figure, fifteen armatures (the wheel on which they were mounted measuring five inches and one-half in diameter), and two electro-magnets. With six cells of a Daniell Battery it proved to have ample power to drive four dial works for dials 5 feet 6 inches in diameter. It may have as many electro-magnets as it has armatures. This is a circumstance of some importance, since it will increase its driving capacity with each additional electro-magnet without adding materially to the size of the instrument.

Whatever the reason may be, there is no doubt that, to this day, the time telegraphs have not received such notice as they really deserve.

Their service can be more useful and general than is mostly admitted. If we consider that we can control by one correct time-piece just as many time telegraphs to indicate true time as necessity or fancy requires, providing there is battery power enough to move them, we have reason to believe that they still may come into general use in hotels and public buildings, where true and equal time in every room of the house is desirable.

But there is still another field of great importance for the time telegraph.

It has been a problem of great perplexity, to this day, with the most ingenious minds of the horological world, how to construct clocks which will overcome the effects of wind and storm beating against the exposed clock dials of public clocks. It is true, Remontoires and Gravity Escapements have been invented to remedy the evil, and clocks may go better with them than without them; but, nevertheless, all these ingenious contrivances have almost as many evils, on account of their complication, as they are designed to avoid. And here it is where the time telegraph has its future. A well-regulated clock, kept at a place of even temperature, will show but very little variation of time. If such a clock controls a time telegraph adapted for tower or public clocks, it will show the time with only such slight variation as will hardly be noticed by the public.

One objection raised against time telegraphs—the use of the galvanic battery—can be an objection no longer. Its treatment is now almost generally understood since it has found its way into so many branches of business of every-day life. There is little room left to doubt that when the utility of the time telegraphs is once recognized it will receive more deserved notice and be brought into more general use; and the time may not be far distant when the subtle power of electricity will regulate all our better class of tower or other public clocks.

International Postage Stamps.—France and Belgium have entered into negotiations for the establishment of a joint postage stamp. If the plan is carried out the payment of small sums could be made between the two countries in stamps. Moreover, in letters requiring answers, stamps could be enclosed for the reply, a thing which is now impossible.—*Chron. Indust.* C.

GAS ENGINES.

Gas engines have lately been brought so prominently before the public at the different exhibitions of gas appliances, held by gas companies in various parts of the country, that a few words about their history, and a short description of those at present in the market, may prove of interest to our readers.

It is not our intention to go deeply into the principles of gas engines, but to give a short *résumé* of what has been done to develop these engines from the earliest up to the present time. That the prejudice that originally existed against this class of engines is being rapidly overcome is evident by the variety of purposes to which they are now being applied. This prejudice was now doubt originated by the failures of the early engines, before the combustion and combination of gases had been thoroughly investigated. The feeling was also greatly increased by the jealousy of small steam engine makers, who saw in these new engines formidable rivals to their own productions, and naturally cried down the new comers.

The first patent for what may really be called a gas engine was taken out in the year 1791 by one John Barber. It is described in his specification as "a patent for using inflammable air for the purpose of procuring motion." Coal, wood or oil, or any other combustible matter was placed in a retort, and the smoke or vapor collected and cooled in a reservoir. It was thence conveyed by an air pump to a compressor or regulating bellows which supplied an exploder. Common air was then injected in due proportion, and the explosion was then effected by means of a light. Here then is roughly the principle of some of the most modern gas engines.

In the year 1794, Thomas Mead obtained a patent for an apparatus by means of which, when air, gas or other elastic fluid came in contact with ignited combustible matter, or felt the power of heat in a confined space, it became decomposed and expanded by the heat, and by the evolution and expansion of its component parts acted on a piston and exerted power. His specification also shows how he obtained a vacuum under his piston which the atmosphere pressed on and forced it back. This is in part the principle on which the Otto and Langen atmospheric engine acted, which is described further on in this paper.

The principle of the hydrocarbon engine, manufactured by George Brayton, of America, and by Messrs. Thompson, Sterne & Co., of Glasgow, was partly anticipated by Robert Street, who in 1794 obtained a patent for an apparatus from which he proposed to obtain motive power by means of a few drops of spirit of tar or turpentine being poured upon the heated bottom of a cylinder, and thus being converted into vapor. Air was then sucked into the cylinder, and an explosive mixture formed, which when ignited forced up the piston, and thus by suitable mechanism gave motion to machinery.

The first mention we find of automatically governed engines is in a patent granted in the year 1833 to Lemuel Wright. The specification mentions that governors were applied to the engine to regulate the quantities of gas or air supplied to the cylinders. Various patents were granted between this time and 1860, which appear to have been more or less improvements of the afore-mentioned patents, but none came into practical use. In 1860 we find a communication from J. Lenoir was granted a patent for an invention consisting of the application and use of an inflammable gas mixed with a proper proportion of atmospheric air, and ignited inside a cylinder by means of electricity. The explosion thereby produced, acting on a piston, produced motion, which was transmitted to a driving shaft. The supply of gas was regulated by a suitable governor. In the same year Pierre Hugon obtained a patent for an engine somewhat similar in principle to the above. These, we believe, were the first two gas engines which came into anything like practical and general use. Later on—in 1860—Pierre Hugon obtained a provisional protection for improvements in his former specification. This applied to an improved method of lighting his charge, for which purpose he used red-hot platinum wires. These engines were made double-acting, and great difficulty was experienced in keeping the cylinders cool. They were found to be uneconomical in practice, and never came into very extended use. A few of them may, however, still be found at work in various parts of the country.

The first patent taken out in connection with the well-known atmospheric gas engine of Messrs. Otto & Langen, of Deutz, near Cologne—afterwards manufactured by Messrs. Crosley Brothers, of Manchester, the present makers of the "Otto" engine—was in the year 1863, and was improved in 1866. In this engine an explosive mixture of air and gas drives up a light piston attached to a rack in gear with a spur wheel on the fly-wheel shaft. This wheel is not connected with the shaft, but, by means of a ratchet wheel or friction clutch mechanism, allows the piston to fly up free of the fly-wheel shaft when the explosion takes place; and on a partial vacuum being formed under the piston by means of the condensation of the products of the explosion, the piston descends by the pressure of the atmosphere. The friction clutch is then thrown into gear, and imparts motion to the fly-wheel shaft. This engine was found to be extremely economical in practice, only 21 cubic feet of gas per indicated horse-power per hour being consumed. Upwards of 4000 engines were made on this principle, and a large number are at present doing good work.

In January, 1874, a communication from Frederick Gilles, of Cologne, was granted a patent for improvements in motors worked by gas, as follows: An elongated cylinder open at one end is provided with two pistons, a loose one, and a "working" one, connected in the usual way to a crank on the main shaft, which is provided with a fly-wheel. Assuming the working piston to be at the extremity of its inward stroke, on turning the fly-wheel it is drawn towards the outer end of its stroke, followed by the loose piston, until the latter is stopped by a crosshead on the rod attached to it. The working piston continuing its movement causes a partial vacuum behind it, in the space between it and the loose piston. The charge of mixed gas and air is then admitted into this space and is exploded. The force of the explosion causes the working piston to move onwards to the end of its stroke, and at the same time forces the loose piston to move quickly in the opposite direction. A vacuum is formed between them, which draws up the working piston, while the loose piston is held fast at the top of the cylinder by suitable mechanism. When the working piston nears the top of its inward stroke, the loose piston is released, and falling rapidly expels the products of combustion at the exhaust valve, and the action is then repeated. As will be seen from the above description, the engine is made with the cylinder vertical. The English licensees were Messrs. L. Simon & Son, of Nottingham, who made several of these engines.

The engine bears a remarkably close resemblance to, and, in fact, may almost be said to have been anticipated by a patent taken out in May, 1864, by Francis Wenham, for "an engine worked by explosive mixtures." The specification describes an engine whose action appears to have been precisely similar to the above. We are not aware, however, that an engine made according to his specification was ever brought out.

In May, 1876, Messrs. Otto & Langen, of Deutz, took out a patent for a gas engine, which, after several modifications and improvements, resulted in the production of the now well known "Otto" silent gas engine, which has since come into such extended use. Indeed, there are few large towns in England where many of these engines may not be found at work. The principle on which this engine works opened an entirely new field to scientists and engineers, and it may be looked on as the forerunner of an entirely new class of gas engines. This was the first engine in which a gradual expansion of the charge of gas and air was utilized, thus insuring great economy in working. By introducing a diluent of atmospheric air, or other neutral gas in sufficient quantity, with a small charge of coal gas, the highly explosive nature of a purer mixture of oxygen and hydrogen, or air and coal-gas, is reduced within an easily manageable compass. The charge is compressed in the cylinder, and then, on a light being admitted, is exploded, or, to speak more correctly, "burned," and this ignition expanding the neutral remainder of the charge, a well sustained and but gradually diminishing pressure is brought to bear on the piston throughout the length of the stroke, and a total absence of shock to the working parts is thus insured. We have seen diagrams taken from these engines at work, and they show a beautifully regular expansive curve, falling gradually from 160 lbs. at the commencement of the stroke, to about 40 lbs. on the opening of the exhaust valve. A chief advantage that this engine possesses over others in the market is that it performs in one cylinder what others are compelled to do in two, namely, the compression and ignition of the charge, the cylinder being used alternately as a pump and a motor. The fly-wheel consequently makes two complete revolutions for one charge of gas when the engine is doing full work. On starting the engine, the first out stroke of the piston sucks in the charge of gas and air, which is compressed by the first inward stroke of the piston; the charge is then fired, and the piston consequently forced outwards again, and the second return stroke, performed by the momentum of the fly-wheel, expels the products of combustion at the exhaust valve, and the operation, as above described, is repeated. The engine is horizontal and single-acting, the charge being admitted behind the piston. The amount of gas used is in proportion to the work taken out of the engine, and is regulated by an extremely sensitive governor. The consumption of gas by the "Otto" when doing full work is about 22 cubic feet per indicated horse-power per hour.

Messrs. Louis Simon & Son, of Nottingham, took out a patent in 1877 for "Improvements in Atmospheric Gas Engines." Atmospheric air is compressed by a pump and stored in a reservoir, from which it is withdrawn and utilized in fixed quantities by suitable valves under control of the moving mechanism after the engine is first started. With the specification is a drawing of a vertical engine with the pump alongside the cylinder. In this arrangement the bed-plate is a hollow casting, and is used as a reservoir for the compressed air. In February, 1878, Messrs. Simon took out a patent for an engine with inverted vertical cylinder and pump, motion being imparted to the crank shaft by means of an oscillating beam and connecting rod. The invention consists in the introduction of steam into the cylinders of gas engines. Steam is expanded by the heat of the cylinder, and by the heat developed by the combustion of a mixture of gas and air, and thus adds power and economizes gas. The engine is somewhat the same in principle as the "Otto," inasmuch as the charge of gas and air is compressed, and ignited under compression, but differs from it in that this engine ignites its charge once for every revolution, and by means of the pump, forces the combustible mixture into the cylinder during a part of the stroke. Eventually the beam was dispensed with, and the engine is now made in the form fully illustrated and described in No. 1203[*], vol. xlvii, of *The Engineer.* It has a novel institution in the shape of a boiler placed on top of the explosion cylinder in which the waste gases are used to raise water to boiling point, and thus, as already pointed out, slightly aid in driving the engine.

It is stated that a pressure of 40 lbs. per square inch is attained in the boiler after the engine has worked a short time. The engine is made single-acting, and is virtually a combination of a gas and steam engine, as it has two elements acting together to produce motion, viz., combustion and expansion of a mixture of gas and air and steam, generated by the heat of the exhausted gases. The diagrams taken from the engine are good. In an improved design of this engine, patented in 1878, it is shown as an ordinary vertical engine with the cylinders below. A hand force pump is added for facilitating starting. This engine is now also made horizontal, and was recently exhibited at an exhibition of gas appliances held in Nottingham.

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[*] January 7th, 1879.

An engine recently shown at an exhibition of gas appliances, held at Bradford, and manufactured by Messrs. S. Clayton & Co. of Bradford, was patented by them in 1878. This engine bears a striking resemblance to the "Otto." It is a horizontal engine, but uses a separate pump underneath the cylinder for drawing in a regulated supply of air, gas or vapor, and forcing the same into the cylinder through a port regulated or controlled by a valve. The gas supply is regulated by a governor, and the charge of air may be either compressed or used at atmospheric pressure. The engine can be made either single- or double-acting, and differs from the two foregoing engines in that the charge may be fired every stroke, or each alternate one, as desired. It also has no slide valve, but instead, uses one of a conical rotary construction, somewhat like an ordinary cock. Having no data, we cannot speak as to the consumption of gas by this engine.

Richard Hellewell, of Blackburn, in 1878, improved on a patent taken out by him in 1877, for a vertical engine with two pistons in one cylinder. When the charge is ignited the loose piston is driven upwards by the force of the explosion, and is held at the top of the cylinder by suitable mechanism. A vacuum is formed, and the other piston, to which is attached the connecting rod, is drawn upwards by means of the vacuum. The loose piston is released when the fast one has reached the top of its stroke and then follows it down the cylinder, and the operation as above described is repeated. It is needless to remark on the similarity this engine presents to others already described.

In December, 1875, Edwin Alexander patented a communication from Alexis de Bischop, of Paris, for a gas engine. The engine is made with a very long, narrow cylinder, so as to accommodate to as great an extent as possible the speed of piston to the explosive force of the mixture of air and gas. The increase in the speed of piston thus obtained affords a longer expansion of the burnt gas. The stroke is made ten or more times the diameter of the piston in length. A piston valve, worked by an eccentric on the fly-wheel shaft, is used in this engine, in lieu of the usual slide valve. The action is as follows: On turning the fly-wheel by hand at starting, the piston is moved upwards, at the same time drawing in a charge of gas and air. When the piston has traversed one-third of its stroke, the admission of gas and air is cut off by the raising of the piston valve, and the charge is ignited. The force of the explosion drives the piston the remainder of its stroke.

The piston is caused to descend by the momentum of the fly-wheel gained during the ascent of the piston after the explosion. At the same time, the products of combustion are forced out of the cylinder at the exhaust valve. The piston, again ascending, draws in a fresh charge, and the action is repeated. The engine is vertical and single-acting, an explosion occurring at every revolution of the crank shaft. The chief peculiarity of the engine is that no lubricant is required, nor water for cooling purposes, the latter being accomplished by radiation. The consumption of gas being very large, the maximum power offered is not equal to half a horse, or thereabouts. No governor is applied. These engines are made in England by Mr. J. Andrews, of Stockport.

In 1878 Mr. Dugald Clark patented an engine now made by Messrs. Thompson, Sterne & Co., of Glasgow, and exhibited at the recent agricultural show at Kilburn. The engine is horizontal and single-acting. The air-pump is placed alongside the cylinder, and the whole engine presents a neat and compact appearance. Air and gas are admitted to the pump by means of a valve, when its piston moves outwards and becomes mixed therein; and on the return inwards of the pump piston, the mixture passes through a lift valve into an intermediate chamber or reservoir constituting the back end piece of both cylinders. The igniting arrangement in this engine is novel. A small piece of platinum wire in the cylinder valve is used for this purpose, which having once become heated, remains so; for each time the mixture passes on its way into the cylinder, and is exploded, the platinum receives as much heat as is necessary to make up for its loss otherwise, and is thus always kept at a red heat sufficient to ignite the charge. In this engine, as in those previously described, the gas and air are used under compression, water also being circulated round the cylinder to keep it cool. In this case a small centrifugal pump is used for the purpose. A governor acts on the gas regulator valve, controlling the supply. The consumption of gas in this engine is stated by the makers to be but 15 cubic feet per indicated horse-power per hour.

In having thus traced the development of the gas engine down to the present time, we have been debarred by want of space from mentioning every patent which has been taken out in connection with them, many of which have never advanced beyond mere provisional protections. We have therefore merely touched on the more important patents, or those in connection with the various engines at present before the public. But that there is a grand future for this class of engines no one will deny; and that the public now feel that they can place confidence in the engines is evinced by the number of new firms which of late have taken up their manufacture. In many cases, where hitherto small steam engines have been exclusively used, gas engines are rapidly taking their places. One very great point in their favor is that no extra insurance premium is generally required. Another great advantage held by gas engines over steam engines is the fact of being able to get full power whenever required at a moment's notice, without the time usually wasted in getting up steam. Moreover, as soon as the gas engine is stopped consumption of fuel ceases, and no steam has to be kept up in case the engine is wanted only at intervals. The electric light scare undoubtedly acted most beneficially for gas engine makers. Apart from the fact that gas engines were in many cases put down to drive the electric light machines, it brought gas companies to their senses, and caused them to supply, in some cases, better and cheaper gas. This was an extra inducement to people to lay down gas engines which had not previously existed. Undoubtedly the fact that gas engines have now proved themselves really reliable motors has induced various trades, where hitherto hand-power has been almost entirely used, to put down a safe and economical motive power, as a means of developing and extending their trade. In many cases power is required where the high insurances on steam boilers have hitherto precluded their use. Gas engines, then, at once step in to overcome the difficulty. With them their is no smoke, no water, no coal to get in, nor ashes and cinders to remove, no boiler to blow up, or at least to insure; no waiting to raise steam or waste in keeping it ready, no stoker, and no cumbrous boiler setting. That some difficulties yet remain to be overcome may be admitted, but that these do not hinder their practical utility is now well proved by the many thousands of them already found in use scattered over all parts of the world.—*Engineer.*

Condensers of Tempered Glass.—G. Ducretet says that recipients of tempered glass, when employed like Leyden jars, are capable of receiving, without being fractured, a strong charge of electricity, and, consequently, of giving condensed sparks of a power far superior to those which are ordinarily obtained. Plates of tempered glass can be employed in the same manner. Leyden jars of very minute dimensions give remarkable results.—*Comptes Rendus.* C.

New Electro-Magnet.—Chambrier increases the power of electro-magnets by augmenting the extent of active surface at the extremity of the core and of the oscillating armature. He indicates various ways of doing this, which are all nearly equivalent in effect; he hollows the core and gives to the armature a projection fitting into the cavity, or he attaches the projection to the core, making it fit a cavity of the armature. A battery of eight or ten elements is as efficient, with his arrangement, as fifteen elements with an ordinary electro-magnet. The residuary magnetism is not increased; it appears rather to be weakened.—*Comptes Rendus.* C.

Torrential Deltas.—Desor gives his assent to the general conclusion of the geologists who have examined the recent terraces of the Cornici, and who regard them as ancient deltas. Instead of being horizontal, they are inclined under an angle of 12 to 20°, like the abundant collections of conglomerates which are found at the mouth of the principal rivers of ancient Liguria. He considers all deltas of this kind as due to the action of mountain torrents, and recommends a careful distinction in future geological study between the torrential deltas and the deltas of large rivers. He believes this distinction is as important in all cases as that which has been established between marine and lacustrine deltas.—*Comptes Rendus.* C.

Experiments upon Rails.—Tresca has published the results of experiments on the flexion of iron and steel rails, between the limits of elasticity and rupture. They show that for these two metals, in their ordinary industrial condition, the coefficient of elasticity is nearly the same and may be designated by the equation $E. = 21 \times 10^9$, thus confirming his special experiments in 1857 and 1859 upon Swedish irons and the cementation steels which are made from those irons. He finds that the limit of elasticity, for a given bar, may be extended in proportion to the energetic actions to which it has been previously submitted, and that the elastic limit may be pushed almost to the point of rupture without the coefficient of elasticity having varied in any perceptible degree. The metal, when it comes from the workshops, is in a manifest state of instability, which disappears only by use; it becomes, by means of the actions to which it is successively submitted in its employment, more homogeneous and more elastic, but at the same time a little more flexible.—*Soc. des Ingen. Civ.* C.

Magnetic Writing.—Prof. Thompson, of Bristol, has lately made an interesting observation in regard to an application of magnetism. He takes a thin plate of hardened steel and writes upon it with a magnetized iron style, thus communicating a tolerably permanent magnetism to the parts of the plate which are covered by the writing. If fine iron filings are sprinkled upon the plate and the plate is then held perpendicular, so as to remove the loose filings, the writing becomes visible upon the magnetized portion. The experiment may be repeated, at pleasure, for an indefinite period.—*Fortsch. der Zeit.* C.

Induction Estimate of the Mechanical Equivalent of Heat.—From the law of conservation of energy it follows that the work which an electric current in a conductor is able to perform must be equivalent to the work which is required to excite the same current in the same conductor through induction. This consideration induced von Waltenhofen, when he was engaged in some experiments suggested by the theory of electro-magnetic machines, to undertake a determination of the mechanical equivalent of heat by means of electricity. The result of his researches was about one-half per cent. less than Joule's equivalent.—*Ann. der Phys. und Chem.* C.

Relation between Pressure, Temperature and Density of Saturated Vapors.—Winkelmann finds a relation which may be expressed by the following equation:

$$t_n = (a + b)\frac{d_n}{n_d} A - a.$$

t_n is the temperature of the saturated vapor under the pressure of n atmospheres; d_n the density of the saturated vapor under the same pressure, the density of air being regarded as the unit; d the density of the vapor as deduced from the molecular weight; A a constant magnitude which is the same for all vapors; a and b two constant magnitudes which depend upon the nature of the vapor. The equation, which holds good for the vapors of all fluids that have been investigated, contains only two constants which vary for different fluids. These constants have a simple significance, for example, if $n = 1$, $t = b$; *i. e.*, b denotes the temperature at which the vapor has the tension of a single atmosphere; if $n = o$, $t_0 = a$; *i. e.*, at the temperature $-a$ the fluid begins to change into vapor.—*Ann. der Phys. und Chem.* C.

Elasticity of Chrome Steel.—In his experiments upon the hydrodynamometer, Pellat found that the elastic resistance of chrome steel could be pushed to a much higher figure than any other metal which he tried, without passing the limit of elasticity.—*Ann. des Ponts et Chauss.* C.

Density of Liquefied Oxygen.—Prof. J. Offret thinks that Pictet was too hasty in assigning a density to liquefied oxygen equivalent to that of water. He points out errors of calculation which reduce the result by Pictet's first method to ·8655, and wholly invalidate his second method. He regards his own figures, however, as merely provisory, and as probably below the true value. Further investigations may perhaps still prove the correctness of Dumas' prediction, that water and liquid oxygen have equivalent densities.—*Ann. de Chem. et de Phys.*

Applications of the Hydrodynamometer.—De Perrodie reports a series of experiments which were undertaken to determine the exact value of the coefficient of the hydraulic dynamometer. Among the uses to which he finds it especially applicable is the measurement of the intensity of the wind. In the same way as balances are made for all purposes, from the most delicate determinations of chemical analysis to the most ponderous weighings in mechanical workshops, hydrodynamometers may be constructed of all degrees of strength, from those which are used in physical laboratories for the minute study of hydrodynamic laws to those which engineers would employ for gauging the force of water at the greatest depths.—*Ann. des Ponts et Chauss.* C.

Crookes' Vacuum.—In his experiments upon radiant matter Crookes required a vacuum of a millionth of an atmosphere. It was obtained by a combination of Geissler's and Sprengel's mercurial exhausters, and measured by McLeod's gauge. Warren de la Rue estimates that the gauge will correctly record a vacuum of one fifteen-millionth of an atmosphere. Precipitated sulphur was used by Crookes in order to absorb the mercurial vapors; metallic copper, reduced from its oxide, to absorb the sulphurous vapors, and sulphuric anhydride to absorb the vapor of water. A small radiometer was employed to show the progress of the vacuum, and a Plücker tube for a similar purpose, the spectrum of the electric spark changing with the degree of rarefaction.*Ann. de Chim. et de Phys.* C.

Passivity of Iron.—Concentrated or fuming nitric acid does not corrode iron; on the contrary, when iron is dipped into it it acquires the singular property of resisting the attacks of diluted acid. The fuming acid is said to render the iron passive. Dumas first called attention to this fact in his lectures. It was afterwards studied by the elder Becquerel, de la Rive and others, who offered various hypotheses to account for the phenomenon. It was commonly thought that a film formed on the surface of the metal, consisting either of an oxide or of an insoluble nitrate, which constituted a sort of varnish and thus prevented any further attack. L. Varenne has found that the passivity depends in great measure upon the degree of condensation in the metal, but that in all cases it may be overcome by shocks, and even by extremely feeble vibrations which are excited by the action of an electro-magnet. Moreover, a current of gas, even though very feeble, usually destroys the passivity. Varenne finally concluded that the phenomenon was entirely due to a gaseous film on the surface of the metal, and his belief was confirmed by finding that the passivity ceased entirely in vacuum. He thinks that the film consists principally of gaseous nitric oxide. He proposes to extend his researches, in order to find what are the causes which lead to the formation of the film, and what is the nature of the influences which afterwards maintain its adherence.—*Ann. de Chim. et de Phys.* C.

Book Notices.

EXPERIMENTS ON THE STRENGTH OF WROUGHT IRON AND OF CHAIN CABLES. By Commander L. A. Beardslee, U. S. N.; revised and abridged by Wm. Kent, M. E. John Wiley & Son, New York. 1879. 8vo, pp. 119.

This very valuable work comprises the details of experimental inquiry into the physical and chemical properties of rolled iron, especially as relates to cable iron, being a portion of the report to the United States Government of the Board appointed to test iron, steel and other metals. It is scarcely possible to overrate its usefulness as a guide for future investigations or for the correct determination of the properties of iron for the purposes immediately considered, or other practical application. The abridgement of the full report is restricted in the main and in all essential regards to the omission of tabular matter which is purely corroboratory to what has been retained, so that this work presents for record a full account of the proceedings of the committee of the Board referred to.

Even a summary of this report would far surpass the limits of a book notice, and it is only to recommend it as an example of positive knowledge available at all future times to the mechanical engineer that any expression of merit can judiciously be made. Still, some particular conclusions may be noticed as of interest to the general reader. It is demonstrated that a studded link cable is, contrary to all previous authority, no stronger than one with open links of the same weight of iron in the round, and much weaker than one with open links when the dimension of iron in the round gives equality of weight to equal length of cable. Again, it is shown that any test of a cable which strains the iron above its elastic limit, so far from adding to the severity by the detection of faults, is an actual source of weakness in developing incipient defects. B.

LABOR AND CAPITAL: ALLIES NOT ENEMIES. By Edward Atkinson. 32mo. New York: Harper Brothers. 1880.

This little volume contains the substance of the argument lately presented to the Congressional Committee on Labor, of which A. S. Hewitt is chairman. Of the great importance of the subject there is not the slightest doubt, and as it involves questions upon which there is a great variety of opinion—concerning money, legal tender, the tariff, a national excise system, the bank question, and perhaps the greatest of all, the problem of National or State interference in the pursuits of citizens for shortening the hours of work, promoting education, and attempting to compass the material welfare of special classes by means of legislation—it is worthy of all the time and thought that can be expended upon it.

The author truly observes that the great forces named, Labor and Capital, are one and the same in essence—allies, not enemies—and that the titles we give them only serve to distinguish the effort of the past that has been saved and not expended from that which is now exerted; but whether these forces shall be brought into conflict or not depends in great degree upon the capacity of those who frame the laws under which the production and distribution of wealth are conducted. We cordially commend the volume to the attention of our readers. N.

OUR HOMES. By Henry Hartshorne, M. D. 18mo. Philadelphia: Presley Blakiston. 1880.

We would be pleased if the carefully prepared volumes of the American Health Primers could be found and read in every home, each additional one seeming more admirable than those that have preceded it. No one could be fitted for the task of writing a volume upon "Our Homes" more eminently than the late Professor of Hygiene in the University of Pennsylvania; and in the different chapters, after some introductory matter of a valuable kind, we have the situation of the house and its construction discussed, the important questions of light, warmth, ventilation, water supply, drainage and disinfection. In that on workingmen's homes a brief account is given of the Building Associations of Philadelphia, where by paying a moderate sum a month the artisan becomes the owner of the property, and which has made Philadelphia so peculiarly a city of homes for all classes. It is one of his highest aims, and in which he nearly always succeeds. The volume, like all in the series, is well printed, and has quite a number of illustrations for the moderate price it is sold for. X.

THE FIELD ENGINEER. By Wm. Friedley Shunk. D. Van Nostrand. 1880. 8vo, tucks.

One of the pocket books for railroad work in the field, "prepared with special reference to the wants of the young engineer." The elementary portion of this work is in one sense prepared in admirable form for practical use. It is set out to be "a compendious exposition of those mathematical truths and methods which the young engineer *must* become familiar with from the beginning. Such familiarity may not be had from the work itself, but it is sure to come to those who will *study* to acquire it from sources readily to be ascertained. Learning backwards is a sure way to learn, but it has the defect of giving more of special than of general knowledge. Any young engineer, however, who will have mastered the truths set down for him to become familiar with will have attained competency in his profession for all ordinary requirements of American practice.

There are given problems covering the demands of daily work in the field, with concomitant tables of reference in computation. B.

Franklin Institute.

Hall of the Institute, April 21st, 1880.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 117 members and 28 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that 14 persons were elected members of the Institute at their last meeting. He also read the following letter:

"Philadelphia, March 27th, 1880.

"William P. Tatham, Esq., *President of the Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts.*

"Dear Sir,—Please accept, in behalf of the Institute, the enclosed one thousand dollar ($1,000) certificate of the 6 per cent. untaxed loan of the city of Philadelphia, due in 1895.

"It is my wish that this amount shall be re-invested, when paid off, in such manner as may be directed by the Board of Managers, and the annual income be used in aid of such apprentices to the machine business as may need assistance to enable them to receive the instruction given by the Institute in mechanical drawing. These pupils to be selected in such manner and under such regulations as may be made by the Board of Managers of the Institute.

"Very truly yours,
"B. H. Bartol."

The Secretary reported that Mr. Lewis S. Ware had a short time ago presented to the Library a valuable set of the "Annales du Genie Civil," and that now he had given a set of the "Annales Industrielles," and the acquisition of such serials and works obtained from the Bloomfield Moore Trust Fund, from Mr. A. E. Outerbridge's lectures, and by purchase from time to time by the Institute, was fast making the Library one of the most important in the country for technical works relating to science and the mechanic arts.

The following donations have been received since the last report:

Accounts of the Operations of the Great Trigonometrical Survey of India. Vols. 2, 3, 4.
From His Excellency the Viceroy and Governor General of India in Council.

Letters of Registration of Inventions. Australia, 1855 to 1876.
Through Robt. Grimshaw, Ph. D.

Catalogue du Ministère de l'Instruction publique des Cultes, etc. Vols. 1—3, in 5 parts. Section Belge. Catalogue Officiel des Œuvres d'Art, etc. From the Minister of Public Instruction, France.

Reports on the Departments of the Exhibition of Pennsylvania State Agricultural Society. Sept., 1879. From C. Henry Roney.

Improvement in Steam Boilers. By Ogle & Burnett, Washington, Ohio.

Annuaire de l'Academie Royale des Sciences, etc., de Belgique. Vol. 46. From the Academy.

Second and Third Annual Reports of the State Board of Health of Massachusetts, 1871 and 1872. From the Board.

History of the Pacific Guano Company. From the Company.

Register of Commissioned, etc., Officers of the Navy of the United States. January, 1880. From the Navy Department.

Almanaque de la Gaceta Industrial. 1880. From the Publisher.

New Jersey Geological Survey. Annual Report of the State Geologist for 1879. From the State Geologist.

Subject Index of Publications of the United States Naval Observatory, 1845—1875. By E. S. Holden.
From the U. S. Naval Observatory.

Report of the Meteorological Office of the Dominion of Canada. By G. T. Kingston. 1878. From the Office.

Croton Water Supply and its Extensions.
From the C. E. Club of the North-west.

Annual Report of the Adjutant-General of Pennsylvania, 1879.
From Jas. W. Latta, Adj.-Gen'l.

American Institute of Mining Engineers. List of Officers, etc. etc.
From the Institute.

Seventh Annual Report of the New Jersey State Board of Agriculture for 1879. From the Board.

Memoir of Isaac Hays. By Alfred Stillé.
From College of Physicians.

American *versus* English Locomotives.

Annual Report of the St. Louis Mercantile Library Association. 1879. From the Association.

Circulars of Information of the Bureau of Education. No. 5. 1879. From the Bureau.

Annual Report of the Chief of the Bureau of Steam Engineering for 1879.

Report on the Herreshoff Boilers. 1878.

Report on the Murphy Grate Bar. 1878.

Report on the Ashcroft Furnace Doors and Grate Bars.

Report on D. C. Green's System of Ventilation. 1879.

Report on the Two Kinds of Coal submitted by the Chesapeake and Ohio Railroad Coal Agency.

Report of a Board of U. S. Naval Engineers on the Herreshoff Boiler, etc., for Steam Yachts. 1879.

Report on Experiments in Boiler Bracing. 1879.

Report on Experiments to ascertain Proportions for Ends of Boiler Bars. 1880.
From the Bureau of Steam Engineering, Navy Department.

Bericht über die Weltausstellung in Paris. 1878. In 9 parts, and 1 Atlas.

Parts 90 to 93 of the Reports of Judges of Exposition of Vienna, 1873.

Account of the Exhibition in Philadelphia in 1876. By Swedish Commission. With Volume of Plates.

Amtliches Verzeichniss der Aussteller in der Weltausstellung in Wien. 1873. From L. Westergaard, Consulate in Philadelphia.

Eleventh (and Twelfth Annual) Reports upon the Improvement of South Pass of Mississippi River.

Letter from the Secretary of War, transmitting Papers relative to the Payment of First Instalment of Compensation to J. B. Eads for Quarter ending Oct. 30, 1879. From the War Department.

Theory of Natural Philosophy. By T. H. Pasley. London, 1836.
From H. W. Miller, 1919 N. Sixth street.

Transactions of the American Philosophical Society. Vol. 6. Part 1. 1804. From H. A. Freeman.

Abstracts of Registers from Self-Recording Instruments, New York Meteorological Observatory, December, 1879, and January, 1880.
From D. Draper, Director,

Mining Review. Vol. 4. London, 1838.

Mining Journal. Vols. 3 and 4. London, 1836 and 1838.

Additional Report of Water Power. By Watering Committee of Philadelphia. 1849. From the Misses Thompson, Philadelphia.

London Engineer for 1877 and 1878.

From W. D. Smith, Engineer, U. S. N.

Mr. Hugo Bilgram read a paper on "Isochronous Governors for Steam Engines," suggested by the discussion at the last monthly meeting, when there appeared to be some difference of opinion as to whether governors could be made isochronous. Mr. Bilgram said that the question could, in fact, be answered both ways, according to the meaning attached to the word isochronous. The periodical admission and action of the steam have a more pronounced action on cut-off than on throttle governors, and the former only were considered by Mr. Bilgram. The cut-off governor exerts its influence upon the admission of steam only at the moment of the cutting off, and then loses all control over the working capacity of the engine until the corresponding moment of the following stroke. During the intervening period the fly-wheel (including all its equivalents in moving parts) regulates the speed within certain limits. Most governors are designed to remove, as rapidly as possible, any cause for a change of speed. The conditions may be examined by supposing the load of an engine, running at a uniform speed, to be suddenly changed, say increased, immediately *after* the moment of cutting off. The work developed during the following half turn of the fly-wheel will be the same as if no change had occurred in the load; but, as the fly-wheel must supply the power to do the increased work, its speed will be reduced accordingly. This reduction during the first period will be a measure or gauge of the amount of adjustment required, and being made by the governor the working capacity of the engine for the second period will be increased as much as the energy of the fly-wheel has been reduced, the increase of load will be balanced, and the speed will continue uniformly, but at a less rate than originally. The change was graphically represented and explained. Such regulation can be accomplished by the common or stable pendulum, if its degree of sensitiveness is suited to the size of the fly-wheel. This relation may be thus expressed: The *sum* of the energy of the moving parts (fly-wheel, etc.) and of the work developed per stroke of the engine should be a *constant* quantity.

If the change of the load should happen at a later moment than immediately after the cutting off, the governor will only effect a partial correction during the first period, and will require two periods to complete the correction. This, also, was graphically represented. The usual objection to this kind of governor is the permanent change of speed following a permanent change of load, but Mr. Bilgram thought this less serious than frequently represented, and pointed out how the remedy generally suggested—an increase of the theoretical sensitiveness of the governor—is invariably a failure.

It appeard from this that isochronous governors theoretically not allowing a change of speed, could not handle a steam engine. The question then arises, "Can a governor be made that, in case of a change of load, though theoretically admitting a temporary departure from the normal speed, will eventually restore the original speed?" This question Mr. Bilgram answered in the affirmative, and proceeded to show how the purpose could be effected by making a governor which should adjust the valve gear somewhat more than necessary to meet the change of load and then withdraw the surplus adjustment by the time normal speed was restored. Diagrams were presented to show that inertia governors would not effect this purpose, nor a combination of an isochronous resistance governor with an inertia governor. The cause of the failure of the parabolic governor was traced to its lack of stability, and Mr. Bilgram pointed out that if a one-speed pendulum could be converted temporarily into a stable pendulum, a successful governor would be produced. A spring reacting upon the balls of a one-speed governor would make the pendulum permanently stable, but by substituting for the spring a slightly leaking air cushion the desired governor would be obtained. Mr. Bilgram then showed how the size of the air cushion (in the form of a cylinder and piston) should be calculated, and said that such a governor would accomplish the desired purpose, that is, produce an over-adjustment, and then retract it as the speed is returning.

Mr. Nystrom said that he fully appreciated the value of Mr. Bilgram's paper. The subject of isochronous governors was very fully discussed before the Committee of Science and the arts two years ago. He (Mr. Nystrom) had disagreed with Mr. Bilgram then, and he disagreed with him now, although he was willing to admit that his friend was theoretically correct. If we turn a cylinder in a good lathe we say that it is practically cylindrical, but if we put it to the test we will find that it is not an absolutely true cylinder. The pendulum of a clock is practically isochronous; it answers the purpose of an isochronous pendulum, yet theoretically it is not isochronous because of the slight variation in the angle of vibration. But isochronous pendulums—the cycloidal—can be made. These are theoretically isochronous, and cycloidal pendulums were tried on clocks in Vienna some years ago, when it was found that they did not keep as good time as common pendulums. Though theoretically more perfect they were not as good in practice. Applying this to the subject of governors, I say that the latter can be made *practically* isochronous. When a governor, running at a constant speed, can keep it almost closed, it is practically an isochronous governor. The water-wheel governor is practically isochronous. It is true that there is a slight variation while the gate is being moved up or down, but it is so slight as to be of no importance. In further illustration of the same point as to the difference between theory and practice, Mr. Nystrom spoke of Prof. Mark's machine for drawing absolutely straight lines, saying that Seller's planer would make lines a great deal nearer straight in practice, although Mark's machine might be theoretically more perfect. In conclusion, he submitted to the good judgment of the Institute that governors can be made *practically* isochronous.

Mr. Bilgram called Mr. Nystrom's attention to a very decided difference between water-wheel and steam engine governors, the former not having the factor of periodicity in the admission of steam to contend against.

Prof. Marks said that he must protest against the use of the word isochronous as applied to governors, since the latter could not become operative until a change of speed had made it necessary for them to act. As to his machine for drawing a straight line, it was only a rough model he had shown, and yet that made a straight line as far as the eye could detect, when comparing it with a line made by snapping a drawn string. Possibly the line was an arc with a radius of 100,000 miles, but it was practically a straight line.

Mr. Nystrom asked the indulgence of the Institute, and said that, though he admitted the correctness theoretically of the position assumed by Messrs. Bilgram and Marks, he nevertheless thought the term isochronous should still be employed to describe governors that are practically perfect. If not, and its use is to be restricted, it might as well be struck from the dictionary of technical terms, for it can really be of no practical use.

The Secretary's report included accounts of Goldschmid's Aneroid Barometers, with Micrometrical Screws, two forms of which were shown; Juvet's Time Globe, showing the time of any place by a glance on the equatorial zone, all the latest geographical discoveries, isothermal lines, and ocean currents; Beck's Large Stage Microscope, made for Dr. Seiler, and having a vertical and horizontal motion of four inches, for sections of the brain, etc., of that size; Green's Extension Tables; Von Laer's Binder for periodicals, each number of which is held in place by a separate thin metal rod, pivoted at one end and locked in position at the other by means of a horizontal latch; Haworth's Turbine Motors for Sewing Machines; and Powell's Burglar Alarm, by which a paper cartridge is exploded when an attempt is made to open a door or window to which it may be applied. Short papers were read on the Hudson River Tunnel; Luminous Paints; Speed of Locomotive Engines; New Gatling Gun; Stewart's Electric Lamp; Engraving and Carving Machines; Pneumatic Dispatch Tubes; Destructive Western Tornadoes; and the Result of the Examination of Silver Ores from Leadville, Colorado.

Mr. D. S. Holman exhibited a new Compressorium he had devised for observations with high powers under the microscope; also a moist chamber, and an apparatus for showing cell structure.

Mr. Mitchell moved that a Committee of Conference be appointed, to consist of five members of the Institute, to meet a similar committee from the State Agricultural Fair Exhibition, and report to the Board of Managers at their next meeting, which was carried.

The President announced that he would appoint the present Committee on Exhibitions.

Prof. Frazer moved for the appointment of a Committee of Chemists, to examine and report on the relative scientific value and novelty of the methods described by experts in a recent will trial, but the consideration of the resolution was, on motion of Mr. McKean, postponed for a month.

Mr. Cartwright moved that the Franklin Institute tender a vote of thanks to Mr. Bartol for his liberal gift to the Drawing Schools of the Institute, which was carried.

There being no further business, the Institute adjourned.

ISAAC NORRIS, M. D., *Secretary.*

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INFLUENCE OF PISTON SPEED ON THE FRICTIONAL AND AIR RESISTANCES OF AN UNLOADED STEAM ENGINE AND ITS CONNECTED LINES OF SHAFTING IN A FACTORY OR MACHINE SHOP.

By Chief Engineer Isherwood, U. S. Navy.

The writer having occasion, during some experiments conducted by him in the machine shop of the New York Navy Yard, to know the power consumed in overcoming the friction of its unloaded engine, and in overcoming the resistance of the unloaded numerous and long lines of shafting with their drums and belts driven by that engine, made, for the two cases, the determinations hereinafter stated of the mean indicated pressures on the steam piston required to give it different speeds varying from 15 to 70 double strokes per minute, both inclusive, and increasing by five double strokes at a time.

The engine experimented with had one horizontal, direct action, non-condensing cylinder, driving a shaft which carried a fly-wheel of 15 feet diameter and 9 inches face, and a drum of 7 feet diameter and 30 inches face. A leather belt, 30 inches wide and 60 feet long, connected this drum with the lines of the machine shop shafting. The following are the dimensions of the steam piston used:

Diameter of the piston,	20 inches.
Diameter of the piston rod,	3½ inches.
Net area of the piston, exclusive of its rod,	309·35 sq. in.
Stroke of the piston,	40 inches.

When the experiments were made with the main belt thrown off, the steam pressure on the piston being exerted in overcoming only the resistance of the engine, *per se*, that resistance was composed of the friction proper, and of the resistance of the air to the moving parts of the engine. The air resistance was due to displacement resistance and to surface resistance; the former being its resistance to the moving crosshead, connecting rod, arms of the fly-wheel, arms of the drum, etc.; and the latter being the resistance to the peripheral surfaces of the piston rod, connecting rod, shaft, fly-wheel, drum, etc.

When the experiments were made with the main belt in action upon the main drum, and driving the various lines of unloaded machine shop shafting together with thir drums and connecting belts, the resistance to the steam pressure on the piston in addition to the above was that due to the peripheral surfaces of these lines of shafting and their drums, to the surfaces of their connecting belts, and to the air displacement by the arms of the drums, etc.

By deducting the steam pressure on the piston required to give it the experimental speeds in the first case from the pressure required to give it the same speeds in the second case, the remainders will be the pressures required to drive the machine shop shafting, *per se*.

In such determinations the air resistance is generally included with the friction resistance proper, the whole being attributed to the latter. And, when the experiments are made with an unloaded engine alone, whose moving parts move slowly and are of great weight comparably with their surfaces, no error of practical value is thereby made. But, in the case of the lines of shafting, the air resistance becomes a very important constituent of the total resistance, for these lines being geared up to an extremely high speed, and having very extensive surfaces relatively to weight in their shafts, drums and belts, the resistance of the air increasing in the ratio of the square of the velocity of the shafting, while that of the friction remains constant, a velocity is practicable with which the air resistance may equal or exceed that of the friction. The current of air created by the face surfaces of fly-wheels and belts is so strongly sensible that the most careless observer cannot fail to be impressed with the power consumed in its production.

In order not to interfere with the regular work of the machine shop, and thus make the experiments without cost, advantage was taken of short favorable occasions, at different times, so that the experiments were not all made during the same day; portions of four days were consumed, but at no great intervals apart.

Two carefully tested indicators, with scales of 16 pounds per square inch per inch, were employed, one at each end of the cylinder, and the motion for them was taken direct from the engine crosshead by means of a long and stiff wooden lever centered upon the wall of the engine house. For each speed of piston, five indicator diagrams were taken from each end of the cylinder, and the mean of the pressures from the whole ten was taken as the true piston pressure for that speed.

During the experiments the journals of all the shafting were lubricated from oil cups of excellent construction, delivering the same quantity of oil per revolution of the shafts. The best sperm oil was used, and no change whatever was made in the manner of lubrication during all the experiments, which was exactly the same as when the engine was doing its regular work with 58 double strokes of the piston per minute.

Although the oil cups were arranged to *deliver* the same quantity of oil *to* the journals per revolution, it does not follow that the same quantity was *received by* them, the tendency being that after a rotary speed was attained at which the centrifugal force was large in proportion to the gravity of the oil, less and less of the latter went on the journals as their speed became higher and higher. If such was the case, the lubrication at the higher rates of speed was less than at the lower rates. As regards the engine journals, this could not have much effect, as their speed of revolution at the highest was within the limits of easy lubrication; but, as regards the journals of the lines of machine shop shafting, the case was very different, their rotary velocity at the highest being exceedingly great, as they were very much geared up. At very high rotary speeds, the writer, in some late experiments on the value of different lubricants, found much difficulty in getting any oil to flow from the cups upon the journals, the centrifugal action keeping back the liquid in the cup, although the feeding was satisfactory enough when the speed was sufficiently reduced to allow the gravity of the oil to overcome the centrifugal action imparted by the rotation of the journals. He was obliged in these cases to mechanically force the oil out of the cup upon the journal by means of a loaded piston.

The experimental results will be found in the following tables, numbered 1, 2, 3 and 4.

TABLE NO. 1, *showing the resistance of the engine, per se, at the experimental speeds of piston; the main belt being removed from the main drum and the engine worked unloaded.*

Indicated steam pressure on the piston, in pounds per square inch.	Number of double strokes made per minute by the steam piston. (Revolutions of engine shaft.)	Indicated steam pressure on the piston, in pounds per square inch.	Number of double strokes made per minute by the steam piston. (Revolutions of engine shaft.)
2·022	15	1·894	40
2·013	20	2·194	45
1·613	25	2·095	50
1·706	30	2·335	55
1·942	35	2·048	60

A simple inspection of the above Table, No. 1, shows that the piston pressure was the same for all the speeds of piston, the discrepancies being irregular, following no law, and very slight absolutely. Trifling inequalities in the friction of the indicator pistons easily account for the differences. The mean of the determinations for the ten different and widely varying speeds of piston is 1·9862 pounds per square inch of piston for the friction resistance of the engine, *per se.*

In the above Table, No. 2, the resistance appears to be constant from 15 to 25 double strokes of piston per minute; but from 25 double strokes upward there is a continual increase in the resistance, due to the causes hereinbefore stated. This increase, though marked, is irregular, owing doubtless to inequalities in the friction of the indicator piston, and to other causes impossible to eliminate or even discover in such experiments. It is highly probable that if the mean steam pressure had been obtained from a greater number of indicator diagrams for each speed of piston, more regularity would have been found.

TABLE NO. 2, *showing the combined resistance of the machine shop lines of shafting, and of the engine, per se, at different speeds of piston; the main belt being in action on the main drum, but with all the tools disconnected and no work being done.*

Indicated steam pressure on the piston, in pounds per square inch.	Number of double strokes made per minute by the steam piston. (Revolutions of engine shaft.	Indicated steam pressure on the piston, in pounds per square inch.	Number of double strokes made per minute by the steam piston. Revolutions of engine shaft.
4·596	15	5·032	45
4·500	20	5·225	50
4·458	25	5·925	55
4·732	30	5·826	60
4·856	35	6·388	65
4·956	40	6·268	70

In the following Table, No. 3, are the results in Tables Nos. 1 and 2 corrected, that is to say, the friction resistance from Table No. 1, of the engine, *per se*, is taken at the constant 1·986 pounds per square inch of piston for all speeds of piston. The resistances in Table No. 2 are corrected by taking a straight base line and laying off on it as abscissæ, by scale, the number of double strokes made by the piston per minute; next, on right-angled ordinates to the base erected at the ends of these abscissæ, laying off, by scale, the experimental resistances in pounds per square inch of piston, and drawing a fair curve through the free ends of the ordinates, leaving as many ends on one side of the curve as on the other, and at the same distances; finally, measuring, by scale, from the base line to the curve on each ordinate for the corrected resistance at the corresponding speed of piston.

The experimental results under the actual experimental conditions are valuable in showing the practical effect of increasing the piston speed on the pressure required to overcome the resistance of the unloaded shafting. This is the point of interest for factories, machine shops, etc., and the experiments show that, owing to the causes hereinbefore stated, this pressure increases in some power of the piston speed, instead of being independent of it and therefore constant at all speeds, as would be the case were the resistance purely frictional. Of course, each factory or machine shop constitutes a distinct problem and requires a separate solution. No general law can be given other than the qualitative one, that the pressure to overcome the resistance of unloaded shafting increases in some ratio of the piston speed. The experimental results also show that the resistance of the unloaded engine apart from the shafting, which resistance is almost one of pure friction, is constant and independent of the piston speed.

TABLE No. 3, *showing the corrected results of the experiments for ascertaining the separate resistances of the engine,* per se, *and of the machine shop lines of shafting,* per se, *at different speeds of piston.*

Number of double strokes made per minute by the steam piston.	Indicated steam pressure on the piston, in pounds per square inch, required to work the engine, *per se.*	Indicated steam pressure on the piston, in pounds per square inch, required to work both the engine and the unloaded shafting.	Indicated steam pressure on the piston, in pounds per square inch, required to work the lines of shafting, *per se.*
15	1·986	4·500	2·514
20	1·986	4·537	2·551
25	1·986	4·594	2·608
30	1·986	4·677	2·691
35	1·986	4·781	2·795
40	1·986	4·922	2·936
45	1·986	5·094	3·108
50	1·986	5·302	3·316
55	1·986	5·552	3·566
60	1·986	5·823	3·837
65	1·986	6·146	4·160
70	1·986	6·469	4·483

The resistance of an unloaded engine and its connected shafting is a *passive resistance* which can be overcome only by an expenditure of power; and as it must be overcome before the engine can move, the pressure equilibrating it must, in the case of a loaded engine, be first deducted from the pressure on the piston shown by an indicator diagram, leaving the remainder for the net pressure applied to the crank pin. The overcoming of this *passive resistance* involves a very serious loss of useful effect, and as the portion of the indicated pressure applied to the crank pin is the only portion available for external work or commercially valuable, the same engine, kept at constant speed, will work more and more economically the more and more it is loaded; hence the principal advantage of using higher and higher mean indicated pressures on the piston; but this advantage grows less and less with each increment of indicated pressure, because the constant pressure required to equilibrate the friction of the unloaded engine and shafting becomes a less and less proportion of the indicated pressure the more the latter is increased. Practically, too, there is the loss due to more heat radiation and to greater steam leakage with each increase of the mean indicated pressure.

In order to appreciate the amount of power absorbed by the resistance of the unloaded engine and shafting of the machine shop of the New York Navy Yard, the following Table, No. 4, has been calculated for the experimental speeds of piston and for the corrected indicated steam pressures on it in Table No. 3. The horses-power thus expended are given separately for the engine, *per se*, and for the shafting, *per se*.

The power expended in overcoming friction reproduces its calorific equivalent in the rubbing surfaces. For a long time all held the belief, still held by many, that the heat produced by the friction of one solid upon another was due to abrasion of the material, or rupture of its cohesion; an idea plausibly sustained by the fact that the smoother and harder a surface was, and the better lubricated it was by an unctuous liquid, the less was its friction when moving under pressure; and the less also was the abrasion of the material. But this explanation is directly refuted by another fact, of which the world long remained in ignorance, namely, that the friction between the molecules of liquids develops heat in absolutely the same manner as the friction between the surfaces of solids, while it is evident that in the case of liquids there can be no abrasion of material. In fact, abrasion diminishes rather than increases the development of heat by the rubbing together of two surfaces.

TABLE NO. 4, *showing the horses-power expended in overcoming the resistance of the engine,* per se, *and of the shafting,* per se, *at the different experimental speeds of piston and for the corrected steam pressures on it in Table No. 3.*

Number of double strokes made per minute by the steam piston.	Horses-power expended in overcoming the resistance of the engine, *per se.*	Horses-power expended in overcoming the resistance of the shafting, *per se.*	Aggregate horses-power expended in overcoming the resistances of the unloaded engine and shafting.
15	1·8617	2·3567	4·2184
20	2·4823	3·1885	5·6708
25	3·1029	4·0747	7·1776
30	3·7235	5·0452	8·7687
35	4·3440	6·1136	10·4576
40	4·9646	7·3394	12·3040
45	5·5852	8·7405	14·3257
50	6·2058	10·3617	16·5675
55	6·8263	12·2571	19·0834
60	7·4469	14·3876	21·8345
65	8·0675	16·8986	24·9661
70	8·6880	19·6116	28·2996

When a body undergoes friction, its molecules are mechanically thrown by the rubbing pressure into increased vibration, their resistance to which is what is known as the resistance of friction, and is directly proportional to the pressure producing the increased vibration. The heat developed by the friction being the result of, is also directly proportional to, the increased molecular vibrations, and, consequently, is directly proportional to the pressure producing them. There can be no other law of friction than this simple one of the direct proportionality of its resistance and of the heat generated by it, to the moving pressure which causes it, and all properly conducted and intelligently interpreted experiments sustain that fact. Hence the powers required to overcome the friction due to a given pressure, moving at different velocities upon a given surface, are directly as the velocities. And the powers required to overcome the friction due to different pressures moving at the same velocity, upon the same surface, are directly as the pressures.

The effect of liquid unguents in diminishing the friction of solid rubbing substances between which they are interposed, is due to the fact that liquids oppose less resistance to increase of molecular vibration than solids. With perfect lubrication, the solids never come in contact, but they nevertheless undergo some friction. The increased molecular vibration is primarily given to the liquid alone, which then communicates a portion of it to the solids. The popular idea that if the solid rubbing surfaces be kept apart by a liquid unguent they will experience no friction is fallacious. Their friction in that case will, indeed, be a practical minimum, and very slight in comparison with what it would be with the surface in contact; but it will exist, and show its existence, in the fact of different solids having different coefficients of friction, with the same unguent, under pressures less than those necessary to produce contact, and with surfaces of the same degree of smoothness. The different friction coefficients of different solid substances, in the same condition as regards sufficient quantity of the same lubricant to prevent contact, pressure per square inch and smoothness of surface, are due to the difference of their resistances to increase of molecular vibration; in this respect, one substance being much better than another for practical use.

Measurement of Electromotive Force.—Pellat uses a method of opposition analogous to that of Poggendorff, combined with an electrometer, which he substitutes for the ordinary galvanometer, thus removing all fear of polarization of the measured element and of the interference of the resistance with the sensibility. Thus Daniell cells, with an internal resistance of 10,000,000 ohms, have been measured with the same electromotive force and with the same approximation as the largest cells. The standard employed was a Latimer-Clarke element; the compensatory circuit was a fine platinum wire; the intensity of the compensatory current was so regulated that each millimetre represented a difference of potential equivalent to a Latimer-Clarke millimetre. With this wire and a capillary electrometer Pellat secures an approximation of one two-thousandth.—*Soc. Franc. de Phys.* C.

NAVAL ARCHITECTURE.

No. 3.

By Chas. H. Haswell, C. E., M. E.
Member American Society of Civil Engineers.

To Compute Displacement Approximately.

Coefficient of Displacement of a vessel is ratio that volume of displacement bears to the parallelopipedon circumscribing immersed body $\frac{V}{L \times B \times D} = C$. *V representing volume of displacement in cube feet, L length at immersed water line, B extreme breadth,* and *D draught in depth of immersion, all in feet.*

Coefficient of Area of a Midship Section in Plane of a Water Line is ratio which their areas bear to that of circumscribing rectangle.

L representing length of water line, and D distance between water lines, both in feet.

Coefficients. By S. M. Pook, Constructor U. S. N.

Rule.—Multiply the length of the vessel at the load line by the breadth, and the product by the depth (from the load line to the under side of the garboard strake) in feet, and this product by coefficient for vessel as follows: divide by 35 for salt water, 36 for fresh water, and the quotient will give the displacement in tons.

Amidship sections range from ·7 to ·9 of their circumscribing square and the mean of the horizontal lines from ·55 to ·75 of their respective parallelograms. Hence the ranges for vessels of the least capacity to the greatest are ·7 × ·55 = ·385, and ·9 × ·75 = ·675.

Merchant ship, very full,	·6 to ·7
“ “ medium,	·58 to ·62
River steamer, stern wheel,	·6 to ·65
Ship of the line,	·5 to ·6
Naval steamer, first class,	·5 to ·6
“ “	·52 to ·58
Merchant steamer, sharp,	·54 to ·58
Half clipper,	·52 to ·56

Brigs, barks, etc.,	·52 to ·56
River steamer, tug boat, medium,	·52 to ·56
Merchant steamer, medium,	·52 to ·54
Clipper,	·5 to ·54
Schooner, medium,	·48 to ·52
River steamer, tug boat, sharp,	·45 to ·5
" " medium,	·45 to ·5
" " sharp,	·42 to ·45
Schooner, sharp,	·46 to ·5
Yachts, sharp,	·4 to ·45
" very sharp,	·36 to ·4
River steamers, very sharp,	·36 to ·42

In the steam launch *Miranda*, when making 16·2 knots per hour, with a displacement of 58 tons, her coefficient was 3.

Coefficients. By C. Mackrow, M. I. N. A.

				Coefficient		
Description of Vessel.	Length.	Breadth.	Mean Draught.	Displacement.	Amidship sec.	Water lines.
Iron Clads	225	45	15	·715	·932	·755
	325	59	24·75	·64	·81	·71
Mail Steamers	350	35	21	·687	·85	·84
	385	42	22	·659	·88	·8
	368·27	42·5	18·71	·516	·812	·635
Merchant, small	220	27	8	·702	·912	·742
	90	15	4	·637	·914	·704
Gunboats	125	23	8	·536	·87	·616
	160	31·3	12	·466	·745	·603
Troop Ships	350	49·12	23·5	·47	·674	·7
	340·5	46·13	15·75	·4	·68	·582
Swift Naval Steamers	337·3	50·28	22·75	·483	·787	·614
	270	42	19	·497	·792	·628
Fast Steamers, R. N.	300	40·27	14	·414	·711	·711

TO COMPUTE CENTRE OF GRAVITY OR BUOYANCY APPROXIMATELY.

$\frac{2}{5}$ to $\frac{9}{20}$ of *mean draught of hull*, using the larger coefficient for full-bodied vessels.

To Compute Depth of Centre of Gravity or Buoyancy Below Meta Centre.

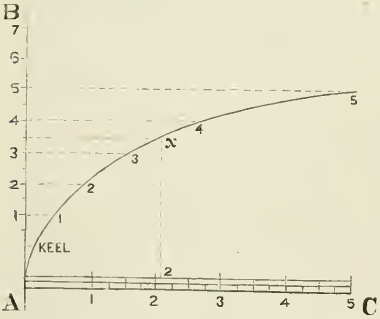
$\frac{S}{D \text{ sin. } M} = d$. *S representing statical stability, D displacement* in tons, *and* sin. *M sine of angle of heel.*

Illustration.—Elements of Fig. 2 (in preceding number, page 290) are statical stability at angle of 5·44° 90 tons, and displacement 204·33 tons.

Then $\frac{90}{204{\cdot}33 \times {\cdot}0999} = 4{\cdot}41$ feet.

To Delineate Curve of Displacement.

This curve is for purpose of ascertaining volume of water or tons weight, displaced by immersed hull of a vessel at any given or required draught; or weight required to depress a hull to any given or required draught. From results of computation for displacement of vessel, proceed as follows, Fig. 3:



On a vertical scale of feet and inches, as *AB*, set off depths of keel and water lines, draw ordinates thereto representing displacement of keel and at each water line in tons.

Through points 1, 2, 3, 4 and 5 delineate curve *A* 5, which will represent displacement at any given or required draught.

Draw a horizontal scale corresponding to weight due to displacement at load line, as *AC*, and subdivide it into tons and decimals thereof, and a vertical line let fall from any point, as *x* at a given draught will indicate weight of displacement at the depth or scale *AC*, and contrariwise a line raised from any point as *z* on *AC* will give draught at that weight.

Illustration.—Displacement of hull (illustration at pages 226–7) at load line = 71518 cube feet, which ÷ 35 for salt water = 204·3 tons, hence *A s* represents tons and is to be subdivided accordingly.

Assume her launching draught to have been 6 feet, then a vertical let fall from 4 will indicate weight of hull in tons on *AC*.

CURVE OF WEIGHT.

To ascertain Number of Tons required to Depress a Vessel One Inch at any Draught of Water Parallel to a Water Line.

Rule.—Divide area of plane by 12, and again by 35 or 36, as may be required for salt or fresh water.

Example.—Area of load water line of a vessel is 1422 square feet. What is its capacity per inch?

$$1422 \div 12 = 108{\cdot}5, \text{ which } \div 35 = 3{\cdot}1 \textit{ tons}.$$

To Compute Common Centre of Gravity of a Vessel.

Rule.—Compute moments of weights of hull, spars, outfits, stores, etc., relatively to assigned vertical and horizontal planes, by multiplying weight of each part by its vertical and horizontal distance from these planes.

Add together these moments, according to their position forward or aft, or above or below these planes, and the difference between these sums will give position forward or aft, or above or below, according to which are the greatest.

Divide results thus ascertained by total weight of vessel, and product will give vertical and horizontal distances of centre of gravity from these planes.

It is customary to assume vertical plane at dead flat, and horizontal plane at load line.

Note.—In following illustration, in order to simplify computation in table, common centre of gravity of machinery, battery, etc., is taken instead of centres of individual parts, as engine, boiler, propeller, etc. etc.

To Compute Centre of Gravity of Bottom Plating of a Vessel.

Longitudinal.

Rule.—Measure half girths of plating at equidistant sections, as at two or more frames. Multiply these in accordance with Simpson's rule for areas and add products together.

Multiply each of these products, in their order, by the number representing the number of intervals of the section forward and abaft of

ILLUSTRATION.—*Vertical Plane at Dead Flat and Horizontal at Load Line.*

Elements of a Steam Frigate.	Weight.	Horizontal Distances.		Horizontal Moments.		Vertical Distances.		Vertical Moments.	
		Forward.	Abaft.	Forward.	Abaft.	Above.	Below.	Above.	Below.
	Tons.	Feet.	Feet.			Feet.	Feet.		
Masts, spars, sails and rigging	24	27		648		31		744	
Anchors and cables	25	40		1000			6		150
Boats	3·25		48		156	16		52	
Battery and ammunition	131·5	62		8153		2		263	
Crew and effects	30	17		510		7		210	
Officers' and mess stores	7·25		40		290		8		58
Water and ship's stores	22	40		880			3		66
Engines, boilers, water and stores	470		29		13630		6·3		3011
Hull and cement in bottom	1075	1·6		1720			1		1075
Provisions and galley	30	1·2		360		5		150	
Coal	252	16		4032			4		1008
Total	2070			17303	14076			1419	5368

Moments before dead flat, 17,303 — moments abaft dead flat, 14,076 = 3227 ÷ weight, 2070 tons = distance of centre forward of dead flat, 1·56 feet

Moments above load line, 5368 — moments below load line, 1419 = 3949 ÷ weight, 2070 tons = distance of centre below load line, 1·91 feet.

dead flat. Divide difference of these moments by sum of products of half girths previously obtained. Multiply product by common distance between sections, and result will give distance of centre of gravity from dead flat in a horizontal plane.

ILLUSTRATION.—Assume half girths as in following table, and distance between sections 10 feet.

FORWARD.

Section.	Half Girths.	Multipliers.	Product.	Multipliers.	Moments.
No.	Feet.				
Dead flat...	25	1	25	–	–
A...........	23	4	92	1	92
B...........	21	2	42	2	84
C...........	19	4	76	3	228
D...........	17	2	34	4	136
E...........	15	1	15	5	75
					615
ABAFT.					
1...........	23	4	92	1	92
2...........	20	2	40	2	80
3...........	18	4	72	3	216
4...........	16	2	32	4	128
5...........	14	1	14	5	70
				534	586

Moments, forward, 615 — moments, abaft, 586 = 29 ÷ total product, 534 = ·054, which × 10 feet = ·54 feet forward of dead flat.

CENTRE OF LATERAL RESISTANCE.

Centre of Lateral Resistance is centre of resistance of water, and, as its position is changed with the velocity of a vessel, it is variable. It is generally taken at centre of immersed vertical and longitudinal plane of a vessel when upon an even keel.

If a vessel is constructed with a drag to her keel, the centre will be moved proportionately abaft of the longitudinal centre.

Yacht *America* had a drag to her keel of 2 feet, and centre of lateral resistance of her hull was 8·08 feet abaft of centre of her length on load line.

CENTRE OF EFFORT.

Centre of Effort is centre of pressure of wind upon sails of a vessel in a vertical and longtudinal plane. Its position varies with area and location of sails that may be spread, and it is usually taken and determined by the ordinary standing sails, such as can be carried with propriety in a moderately fresh breeze.

In computing this position, the sails are assumed to be braced directly fore and aft.

NOTE.—Centre of effort of sails, to produce greatest propelling effect, must accord with capacity of vessel at her load line, compared with fullness of her immersed body at its extremities. Thus a vessel with a full load line and sharp extremities below, will sustain a higher centre of effort than one of dissimilar capacity and construction.

TO COMPUTE LOCATION OF CENTRE OF EFFORT.

RULE.—Multiply area of each sail in square feet by height of its centre of gravity above centre of lateral resistance in feet, divide sum of these products (moments) by total area of sails, and quotient will give height of centre in feet.

2. Multiply area of each sail in square feet, centre of which is forward of a vertical plane passing through centre of lateral resistance, by direct distance of its centre from that plane, and add products (moments) together.

3. Proceed in like manner for sails that are abaft of this plane, add their products together and centre of effort will be on that side which has greatest moment of sail.

EXAMPLE.—*Assume Elements of Yacht America as Rigged when in U. S. Service.*

Sail.	Area.	Height of cent. of gravity of sails.	Vertical moments	Distance of centre of gravity of sails. Forward	Abaft.	Moments Forward	Abaft.
	Sq. feet.	Feet.					
Flying Jib..	65	28	18368	52		34112	
Jib	1087	26	28262	32		34784	
Foresail......	1455	34	49470		3		4365
Mainsail.....	2185	35	76475		40		87400
	5383		172575			68896	91765

$\frac{\text{Vertical moments}}{\text{Area of sails}}\ \frac{172575}{5383} = 32{\cdot}06 =$ *height of centre above centre of lateral resistance.*

Moments $\frac{68896 \sim 91765}{5383} = 4{\cdot}25 =$ *distance of centre abaft centre of lateral resistance.*

RELATIVE POSITIONS OF CENTRE OF EFFORT AND OF LATERAL RESISTANCE.

For square rigged vessel $\frac{L\,(\cdot 75\, d' + d'')}{10\,(d' + d'')} = E.$

For fore and aft rigged vessel $\frac{L}{10\,(d' + d'')} = E$ and $\frac{4\,A}{5\,d} = E'$. *L representing length of load line, d distance of centre of buoyancy of vessel below load line, d′ distance of centre of lateral resistance abaft centre of load line, d″ distance of centre of buoyany before centre of load line, E distance of centre of effort before centre of lateral resistance, and E′ distance of centre of effort above centre of lateral resistance.*

META CENTRE.

Meta centre of a vessel's hull is determined by location of centre of gravity or buoyancy of immersed bottom of hull, for it is that point in transverse section of hull, where a vertical line raised from its centre of gravity or buoyancy intersects a line passing through centre of gravity of hull, as Fig. 3, page 290.

TO COMPUTE HEIGHT OF META CENTRE.

By Moment of Inertia $\frac{I}{D} = M$. *I representing moment of inertia of area of water line or plane of flotation and D volume of displacement in cube feet.*

NOTE.—"Moment of inertia" of an area is sum of products of each element of that area by square of its distance from axis, about which moment of area is to be computed.

TO ASCERTAIN MOMENT OF INERTIA APPROXIMATELY.

Rectangle $= CLB^3$ $C = \frac{1}{12}$: when $L = 4B : C = \frac{3}{50}$, $= 5\,B$: $C = \frac{11}{200}$, $= 6\,B$ $C = \frac{1}{20}$.

With very fine lines and great proportionate length $C = \frac{1}{25}$.

L and B measured at Load Line.

BY MOMENT OF INERTIA.

ILLUSTRATION.—Assume length of vessel 233 feet, breadth 43, draught 16 and displacement 2700 tons. Length = 5·65 beams; hence C is taken at $\frac{21}{400}$. Volume of displacement = 2700 × 35 = 92,500 cube feet.

Then $\frac{21 \times 233 \times 43^3}{400 \times 92500}$ 10·51. Exact height was 10·44 feet.

BY ORDINATES.

RULE.—Divide a half longitudinal section of load water line by ordinates perpendicular to its length, of such a number that area between any two may be taken as a parallelogram. Multiply sum of cubes of ordinates by respective distances between them, and divide two-thirds of product by volume of immersion, in cube feet.

ILLUSTRATION.—Take dimensions from Figs. 1 and 2, p. 225.

ORDINATES.

	Length.	Cube.
4	5·	125
3	7·7	456
2	9·5	857
1	3·9	970
Dead flat.	10·	1000
A	9·6	885
B	7·8	475
C	6·8	314
D	4·	64
		5146
		10
		51460
		2
		3)102920
	7151·8)	34306·6
		4·77 feet.

BY AREAS.

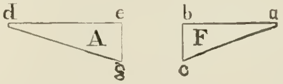
$$\frac{\frac{2}{3}\,(a^3+4b^3+2c^3+4d^3+e^3)\,\frac{l}{3}+F+A}{D}=M$$

a, b, c, d and e representing ordinates of 1*st or load water line, F area of irregular section between* 1*st frame taken and stem, and A area of like section between last frame and stern post, in square feet, D displacement, in cube feet, and l distance between frames or sections of water line, as may be taken, in feet.*

If there are more ordinates, their coefficients must be taken in like manner, as 1-4-2-4-2-4-1.

For operation of this method, see Simpson's rule for areas.

To ascertain Areas of F and A.



$$\frac{\frac{2}{3}\;a\,b\times b\,c^3}{4}=F \text{ and } \frac{\frac{2}{3}\;d\,e\times e\,g^3}{4}=A$$

WHAT IS THE MOST ECONOMICAL POINT OF CUT-OFF FOR STEAM ENGINES?

By Wm. D. Marks,

Whitney Professor of Dynamical Engineering, University of Pennsylvania, Phila.

Probably no question is more frequently asked, and has hitherto received more unsatisfactory replies from the experts in steam engineering, than What is the most economical point of cut-off for steam engines?

Some writers have recommended that the point of cut-off should be determined by dividing two by the square root of the steam pressure in pounds per square inch, although they have not stated their reasons when they stated their facts; others have passed this point over in silence, and still others have endeavored to determine the point of cut-off, giving the most economical results by many and costly experiments.

When we reflect upon the fact that nearly every man, woman and child in this country has laboring for it one horse-power in its steam engines, the immense saving derivable from a ready rule for the economical adjustment of the expansion of steam will appear in all its importance, and the writer therefore hopes that the following original investigation and enunciation of a simple rule will prove of much interest and profit to all using steam.

It will at once be perceived that the work done during one stroke of an engine is equal to the mean pressure multiplied by the volume of the cylinder swept through by the piston.

Let P = the mean pressure in pounds per square inch (absolute).
" P_h = the initial " " " "
" B = the back " " " "
" e = the fractional part of the stroke at which the steam is cut off by the valve motion.
" V = the volume of the steam cylinder.
" E = the economy.

Now it will further be acknowledged that the economy increases directly as the work done during one stroke and inversely as the steam used during one stroke. Therefore we have

$$E = \frac{P V}{e V} = \frac{P}{e} \qquad (1)$$

We have further the well known formula for the mean effective pressure of steam used expansively, supposed to expand according to Mariotte's law—

$$P = e\, P_b \left[1 + l. \frac{1}{e} \right] - B \qquad (2)$$

While this does not accurately represent the law of expansion of steam, it does it with close approximation, for all practical purposes. Substituting the value of P from equation (2) in equation (1), we have

$$E = P_b \left[1 + l. \frac{1}{e} \right] - \frac{B}{e} \qquad (3)$$

Differentiating with respect to e, and seeking the maximum, we find it to be

$$e = \frac{B}{P_b} \qquad (4)$$

That is, *the fractional part of the stroke giving the most economical point of cut-off for a steam engine equals the absolute back pressure per square inch divided by the absolute initial pressure of the steam per square inch.*

EXAMPLE.—In a condensing engine, let the gauge pressure = 45 pounds, and the absolute back pressure = 3 pounds.

$$e = \frac{3}{45 + 15} = \frac{1}{20} \text{ of the stroke.}$$

If the engine be supposed non-condensing, and the absolute back pressure = 15 pounds (1 atmosphere), we have

$$e = \frac{15}{60} = \frac{1}{4} \text{ of the stroke.}$$

If in equation (3) we substitute the value of $e = \frac{B}{P_b}$ we have

$$E = P_b \left[1 + l. \frac{P_b}{B} \right] - P_b = P_b\, l. \frac{P_b}{B} \qquad (5)$$

which gives us a comparative estimate of the economy of the condensing and non-condensing engines having the same initial pressures.

Thus, for the non-condensing engine we have

$$E = 2{\cdot}3026\ P_b \log. \frac{P_b}{B}$$

or

$$E = 2{\cdot}3026 \times 60 \times 0{\cdot}60206 = 83{\cdot}17$$

and for the condensing engine we have

$$E = 2{\cdot}3026 \times 60 \times 1{\cdot}30103 = 179{\cdot}74$$

showing that, when both engines are worked to the best advantage, the condensing engine is more than twice as economical as the non-condensing engine. The writer proposes to add a more exact demonstration in the near future, but engineers will find the above method simple and exact enough for all ordinary practical purposes.

April 23d, 1880.

THE DECIMAL GAUGE.

By Robt. Briggs, C.E.

The Society of Telegraphic Engineers of London have had under consideration the subject of a gauge for wires to be used for telegraphic purposes. The conclusions of the committee (as reported in the *La Lumière Electrique* for Feb., 1880, which is the source from which the writer derived his knowledge of the action of the English society) correspond in some regards to the argument of the paper relating to a decimal gauge which appeared in the Journal of the Franklin Institute for December, 1877. Thus it is recognized at once that there exists a real necessity for a gauge for thickness of metal which shall not follow an arithmetical progression, but which shall give a constant proportionate ratio of decrement or increment, or, in other words, follow a geometric progression.

The ratios of progression proposed in the Journal in 1877 as expressed as relating to *the thickness* of the several numbers of the gauge were

For decrement $\alpha\ 0{\cdot}9^{N}$ or $= \frac{1}{10}$ successive reductions.
For increment $\alpha\ 1{\cdot}11111^{N}$ or $= \frac{1}{9}$ successive increases.*

---

* It will be noted that the increases of thickness for each number of the scale of $\frac{1}{9}$ are made by dividing the value below by 9, extending the division one decimal point in each instance, and that increases of weight for each number of the scale are made by two similar divisions.

These ratios gave, for the sections of squares or of rounds, or for the ratios of weights of equal lengths,

$\alpha\ (0{\cdot}9)^{2N} = (0{\cdot}81)^{N}$ = the second reduction of $\frac{1}{10}$ successively,

$\alpha (1{\cdot}11111)^{2N} = (1{\cdot}234567\dot{9}\dot{0})^{N}$ = the second reduction of $\frac{1}{9}$ successively,* or the values of successive numbers of the gauge.

The ratios of progression proposed by Mr. Clark, and which seem to have met the approval of the Committee of the Society of Telegraphic Engineers are made to relate primarily to the sections or weights, and secondarily to the thicknesses or diameters. Mr. Clark proposes that the relations to the sections or weights of equal lengths of the several numbers of the gauge shall be expressed

For decrement $\alpha\ 0{\cdot}8^{N}$ or $= \frac{1}{5}$ successive reduction.

For increment $\alpha\ 1{\cdot}25^{N}$ or $= \frac{1}{4}$ successive increase.

These ratios give, for the thicknesses or diameters,

For decrement $\alpha\ 0{\cdot}89443^{N}$ or $= \frac{1}{9.4724}$ successive reduction.

For increment $\alpha\ 1{\cdot}11801^{N}$ or $= \frac{1}{8.47386}$ successive increase.

If a metal gauge were adaptable solely to the uses of telegraphic engineers, the question of desirability for definite and aliquot relations of consecutive values might be referred to the derived sections or weights. But the necessities of commercial mechanisms apply generally to sheets as well as to wires, to diameters of wires as well as to their resulting weights, and it would seem that the consideration of the subject by any and each of the parties interested in the result should extend to the general utility. The writer also thinks that examination by telegraphic engineers will develop the fact that computation of weights and conductivities can be quite as readily effected by the two successive steps of decimal notation as by the single one which involves two processes in one case—a division and subtraction (or a multiplication by two figures) for decrement; or by multiplication by eight and movement of decimal point in the other, for increment. While it must be asserted that there are times when the ratios of diameters of wires is desirable knowledge to the telegraphic engineer, such ratios being entirely unattainable by Mr. Clark's system, except by comparisons of values of odd or even numbers of the gauge, which latter of course follow the ratios of weight or section, 0·8 or 1·25 reciprocally.

Whatever may be the scale of gauge adopted, the values as compared with linear, superficial or solid units must be tabular. Although, by the proposed scale of decimal diminutions, each number referred to its following or preceding one has a comparatively simple ratio, yet when two remote numbers (some three or more grades apart) are to be compared in any relation of thickness, section or weight, simplicity of proportion will have been lost; and facility for use demands tables for reference. Such tables for many requirements, and for telegraphic engineers in particular, must be largely of reciprocal values. It is for reciprocal values that a system of progressive differences becomes superior to one of arithmetical differences. In the former system the ratios of reciprocal values are themselves reciprocal, while in the latter system the awkward figures which proceed from the attempt to express in decimal fractions the reciprocals of natural numbers, so generally prime to the decimal notation, bear so complicated a relation to each other that the relationship is unavailable in practice.

Thus, by the proposed system of the writer, the weights of equal lengths of squares or of rounds, for consecutive numbers of the gauge, are, as before quoted,

$a \times 0{\cdot}9^{2N}$ for decrement of diameter or side of square,

and are: $a \times 1{\cdot}11\ddot{1}^{N}$ for increment. " " "

And the reciprocals of these weights, or the lengths corresponding to any given weight, are expressed by

$\frac{1}{a} \times 1{\cdot}11\ddot{1}^{N}$ for decrement of diameter or side of square.

$\frac{1}{a} \times 0{\cdot}9^{2N}$ for increment " " "

In applying the system to electrical measurements, the values for conductivity and for resistance will be computed, the one after the first pair and the other after the second pair of these formulas.

To complete the applications of the proposed decimal gauge the writer has prepared the following tables, which would replace others or supply a deficiency of similar tables in the hand-books of the telegraphic engineers.

TABLE. DECIMAL WIRE GAUGE

Dimensions, Weights, Conductivities and Resistances at 0° Centigrade = 32° Fahrenheit, of Copper Wire annealed. Specific gravity taken at 8·891. Resistance derived from Reports of Committee on Electrical Standards, British Association for Advancement of Science.

"Resistance of pure copper wire, annealed, 1 metre long, 1 millimetre in diameter = 0·02057 ohm."

	VALUES IN METRIC UNITS.						VALUES IN ENGLISH UNITS.				
Number of gauge.	Diameter in centimetres.	Weight per metre of length in grammes.	Length in metres corresponding to one kilogramme or gramme.	Conductivity = length in metres per ohm.	Resistance of each metre in ohms.	Resistance of each nautical mile = $\frac{1}{60}$ degree of longitude in ohms.	Diameter in inches.	Weight per foot of length in pounds.	Length in feet corresponding to one pound.	Conductivity = length in feet per ohm.	Resistance of each foot in ohms.
0	1	2	3	4	5	6	7	8	9	10	11
—3	1·3717	1·313·91	0·76109	9147·7	0·0001093	0·20245	0·5401	0·88290	1·1326	30013·	0·00003332
—2	1·2346	1·064·27	0·93960	7409·6	0·0001349	0·24994	0·4861	0·71515	1·3242	24310·	0·00004114
—1	1·1111	0·862·06	1·1600	6001·8	0·0001666	0·30857	0·4375	0·57927	1·7263	19691·	0·00005079
0	1·	0·698·27	1·4321	4861·4	0·0002057	0·38096	0·3937	0·46921	2·1312	15950·	0·00006270
1	0·9	0·565·60	1·7680	3937·8	0·0002539	0·47031	0·3543	0·38006	2·6311	12920·	0·00007440
2	0·81	0·458·13	2·1828	3189·6	0·0003135	0·58063	0·3189	0·30785	3·2483	10465·	0·00009556
3	0·729	0·371·09	2·6948	2583·6	0·0003870	0·71683	0·2870	0·24936	4·0102	8476·4	0·0001180
4	0·6561	0·300·58	3·3269	2092·7	0·0004778	0·88497	0·2583	0·20198	4·9510	6865·9	0·0001456
5	0·5905	0·243·47	4·2822	1695·1	0·0005899	1·0926	0·2324	0·16360	6·1125	5561·4	0·0001798
6	0·5314	0·197·21	5·0709	1373·0	0·0007283	1·3489	0·2092	0·13252	7·5459	4504·7	0·0002220
7	0·4883	0·159·74	6·2601	1112·1	0·0008992	1.6652	0·1883	0·10734	9·3162	3648·8	0·0002741
8	0·4305	0·129·39	7·7285	900·84	0·001110	2·0559	0·1695	0·08695	11·501	2955·6	0·0003383
9	0·3874	0·104·81	9·5410	729·68	0·001371	2·5381	0·1525	0·07043	14·199	2394·0	0·0004177
10	0·3487	0·084·894	11·7790	591·04	0·001692	3·1335	0·1373	0·05705	17·528	1939·1	0·0005157
11	0·3138	68·764	0·01454	478·74	0·002089	3·8685	0·1236	0·04621	21·639	1570·7	0·0006367
12	0·2824	55·699	0·01795	387·78	0·002579	4·7759	0·1112	0·03743	26·715	1272·3	0·0007860
13	0·2542	45·116	0·02217	314·10	0·003184	5·8962	0·10008	0·03032	32·981	1030·5	0·0009704
14	0·2288	36·544	0·02736	254·42	0·003931	7·2792	0·09007	0·02456	40·716	834·74	0·001198
15	0·2059	79·601	0·03378	206·08	0·004853	8·9867	0·08106	0·01989	50·279	676·14	0·001476
16	0·1853	23·977	0·04170	166·93	0·005991	11·095	0·07296	0·01611	62·073	547·67	0·001826
17	0·1688	19·421	0·05149	135·21	0·007396	13·697	0·06566	0·01305	76·628	443·61	0·002254
18	0·1560	15·731	0·06357	109·52	0·009130	16·910	0·05909	0·01057	94·607	359·33	0·002783
19	0·1351	12·742	0·07848	88·712	0·01127	20·877	0·05318	0·008562	116·80	291·06	0·003441
20	0·1216	10·321	0·09689	71·857	0·01392	25·774	0·04787	0·006935	144·20	235·75	0·004242
21	0·1094	8·360	0·11962	58·204	0·01718	31·819	0·04307	0·005618	178·00	190·96	0·005237
22	0·09848	6·772	0·1477	47·145	0·02121	39·283	0·03877	0·004550	219·78	154·68	0·006465
23	0·08863	5·485	0·1823	38·188	0·02618	48·498	0·03489	0·003686	271·30	125·29	0·007981
24	0·07977	4·443	0·2251	30·932	0·03233	59·874	0·03140	0·002985	335·01	101·48	0·009854
25	0·07179	3·599	0·2779	25·055	0·03992	73·918	0·02864	0·002418	431·56	82·202	0·01219
26	0·06461	2·915	0·3431	20·294	0·04928	91·257	0·02544	0·001959	510·46	66·584	0·01502
27	0·05815	2·361	0·4235	16·438	0·06083	112·66	0·02289	0·001587	630·12	53·933	0·01854
28	0·05233	1·912	0·5230	13·315	0·07510	139·09	0·02060	0·001285	778·21	43·686	0·02289
29	0·04710	1·549	0·6456	10·795	0·09263	171·72	0·01854	0·001041	960·61	35·385	0·02826
30	0·04239	1·255	0·7987	8·736	0·11447	212·00	0·01669	0·0008432	1186·0	28·662	0·03489
31	0·03815	1·0164	0·9398	7·0762	0·14132		0·01502	0·0006830	1464·1	23·216	0·04318
32	0·03434	0·8233	1·2146	5·7317	0·17447		0·01351	0·0005532	1807·7	18·805	0·05318
33	0,03039	0·6669	1·4995	4·6427	0·21539		0·01217	0·0004481	2231·6	15·232	0·06565
34	0·02781	0·5402	1·8512	3·7606	0·26591		0·01095	0·0003630	2754·8	12·338	0·08105
35	0·02503	0·4375	2·2857	3·0461	0·32828		0·009856	0·0002940	3401·4	9·9939	0·10006
36	0·02253	0·3544	2·8217	2·4673	0·40530		0·008870	0·0002381	4199·9	8·0950	0·12353
37	0·02028	0·2871	3·4831	1·9985	0·50038		0·007983	0·0001929	5184·0	6·5570	0·15251
38	0·01825	0·2325	4·3011	1·6188	0·61773		0·007185	0·0001562	6402·0	5·3112	0·18828
39	0·01642	0·1883	5·3107	1·3112	0·76265		0·006466	0·0001266	7898·9	4·3020	0·23245
40	0·01478	0·1526	6·5531	1·0621	0·94151		0·005819	0·0001025	9852·2	3·4847	0·28697

Table for Calculating Resistance or Conductivity of Pure Metal as affected by Differences of Temperature.

Data from Lecture of Fleeming Jenkin, Esq., Reports of British Association for the Advancement of Science.

“$R = r\,(1 + 0{\cdot}003824\,r \quad 0{\cdot}00000126\,r^2)$” “approximate or mean formula.”

[Temperatures in degrees Centigrade.]

Temp. C.	Resistance.	Conductivity.	Temp. C	Resistance.	Conductivity.
0°	1·00000	1·00000	100°	1·395	0·71685
1	1·00383	0·99619	21	1·08086	0·92519
2	1·00765	0·99240	22	1·08474	0·92188
3	1·01148	0·98865	23	1·08861	0·91860
4	1·01532	0·98492	24	1·09250	0·91533
5	1·01915	0·98121	25	1·09639	0·91208
6	1·02299	0·97751	26	1·10028	0·90885
7	1·02683	0·97386	27	1·10417	0·90565
8	1·03067	0·97023	28	1·10806	0·90248
9	1·03452	0·96663	29	1·11196	0·89932
10	1·03837	0·96305	30	1·11585	0·89618
11	1·04222	0·95949	31	1·11976	0·89305
12	1·04607	0·95596	32	1·12366	0·88995
13	1·04993	0·95245	33	1·12756	0·88686
14	1·05379	0·94896	34	1·13147	0·88380
15	1·05765	0·94550	35	1·13539	0·88075
16	1·06151	0·94206	36	1·13930	0·87773
17	1·06537	0·93864	37	1·14321	0·87473
18	1·06924	0·93524	38	1·14713	0·87174
19	1·07311	0·93187	39	1·15105	0·86877
20	1·07698	0·92852	40	1·15498	0·86580

Chlorhydrate of Phosphuretted Hydrogen.—The analogies between phosphuretted hydrogen and ammonia, which are indicated by the formation of compounds with bromhydric and iodhydric acid, are well known. Ogier has also obtained a chlorhydrate of phosphuretted hydrogen by chilling or compressing a mixture of the two gases $PH_3 + HCl$ in equal volumes. The experiment may be easily performed in the Cailletet apparatus; under a pressure of about twenty atmospheres and a temperature of 14° (57·2°F.) the upper part of the tube is covered with small brilliant crystals.—*Bull. Soc. Chim.* C.

REVIEW OF THE REPORT ON THE IRWIN INJECTOR.

By Wilfred Lewis, M. E.

The report of the Committee on Science and the Arts, published in the February number of the Journal, and containing a series of experiments upon the injector and ejector of J. H. Irwin is valuable rather for the experiments themselves than for the deductions and views gathered from them. The generalization of observed facts, and their subjection to known laws and principles, is, however, the most important part of experimental research. It is by this means that new relations are discovered, and better knowledge is gained, without which improvement must be more or less accidental and uncertain.

A crude general theory for the action of injectors is well known to all who are familiar with the instrument; but something more definite is needed before it is possible to determine theoretically the performance of an injector under various conditions from the dimensions of its parts, or what is perhaps of greater importance, to determine the proper proportions for certain desired results.

The present subject is surrounded by so many difficulties and apparent contradictions that any attempt to develop a satisfactory theory upon fundamental principles can hardly be expected to be at once successful. It is therefore only in the hope that a better understanding may ultimately be reached that the following theories and criticisms are offered:

In the first place, it has been claimed for the Irwin Injector that it is constructed on a certain fixed rule of proportion of parts, the discovery of which proportion is the important feature of the invention. The value of the discovery is further claimed to be demonstrated by experiments showing that an injector constructed on this new formula has a wonderful power of augmentation.

The determination of this property of the injector seems to have been the primary object of the experiments, while another more important one, namely, that of "range," has been left in the background.

With this supposed object in view the results are perhaps as good as occasion may ever require, but, with few exceptions, the demand upon an injector is not to overcome pressures greatly in excess of the steam pressure, but to be able to supply water to a boiler at the rate of evaporation, whether this be slow or rapid, and this ability to vary the quantity of delivered water is what is understood by the term "range."

It is well known among manufacturers of these instruments that one desideratum can only be perfected at the sacrifice of others, and that injectors which give good results for range have less power of augmentation, and *vice versa.*

It is therefore difficult to understand how any rules for the proportions of parts can be made general; and how an injector, which gives such good results for augmentation as that of Mr. Irwin, could have been made, as we are led to suppose, according to a law governing its economic action.

The power of augmentation depends upon the velocity and density of the fluid jet in its passage from the combining to the delivery tube, the velocity, in turn, depends upon the proportion of water to steam, and the density, to some extent, upon the duration of their contact before leaving the combining tube.

The less the proportion of water thrown, the higher the velocity and temperature of the mixed water and steam, the slower the rate of condensation and the shorter the time of contact, from which it can be inferred that the proportions favorable to augmentation would be a larger steam nozzle with a longer combining tube than could reasonably be used on an injector designed for economic action. When the injector is used as a boiler feeder its action is economic under all circumstances, and its duty, as stated in the report, is comparatively unimportant, but when used as an ordinary pump the increased temperature of the feed water may no longer be regarded as a useful form of energy, and the economy must be measured by the mechanical effect produced.

For such a purpose, then, the greater the amount of water thrown, and consequently the slower the velocity of the fluid jet within the working limit, the greater the economy as far as mechanical effect and the slight losses by radiation are concerned. The water pressure is in most cases equal to that of the steam producing the jet, and the problem long sought has been to increase the range, that is, to vary as much as possible the quantity of water thrown, in order that a boiler may always be suplied at the rate of evaporation.

The greatest range can be obtained when the greatest possible amount of water is thrown with the steam jet full open. As the steam and water are shut off, the velocity of the mixture must increase, while its density must necessarily decrease, from the fact that a smaller quantity of fluid has to pass through the same sized openings. In order that the fluid of lighter density may overcome a constant resistance, it is evident that its velocity must be increased, and this can only be done by the reduction of the ratio of water to steam.

To determine theoretically the possible range for an injector, it is necessary to know the velocity of efflux of steam and the precise nature of the causes which operate to break the jet.

The most obvious of these causes are want of velocity and density, pressure at the overflow and friction. When the effects of friction and pressure at the overflow can be accurately determined, the injector itself should furnish the best data for computing the velocity of steam, upon which authorities so widely differ. The effects of friction become apparent in the augmentation and range of similar injectors which differ principally in size, and might be determined from a comparison of the results.

The quantity of water delivered depends more upon the conditions at the overflow than upon the pressure overcome, and experiments have shown that there is often no difference between the quantity delivered into the atmosphere and that delivered into the boiler. The reason is clearly because it is not possible to transmit pressure through an open jet except by the pressure surrounding it, and so long as the conditions at the overflow remain constant, the velocity and density of the jet on leaving the combining tube are independent of the pressure afterwards overcome by it. When there is pressure at the overflow the force of the jet will be affected by the density of the fluid producing that pressure as well as by the pressure itself, and when water accumulates, the power expended in its agitation must be sufficient to explain in part the higher degrees of augmentation which can be obtained with waste at the overflow. In the absence of more accurate knowledge, approximate data for computing the velocity of steam might be obtained from an experiment of the following kind:

Let the injector be in full operation, with overflow open, and let the resistances to the delivered water be increased until waste commences, then the pressure equivalent to the combined effects of pressure and friction has become equal to that due to the average velocity and density of the jet. The quantity of water delivered and the total pressure overcome are sufficient data for determining the velocity and density of the jet. The velocity of the jet multiplied by the ratio, plus one of water to steam, will give the velocity of steam. In this experiment, the larger the injector the smaller the effect of friction, and the more reliable will be the result.

It is claimed in the report that the free entrance of atmospheric air at and through the overflow gives a clear gain to the extent of one atmosphere in the same direction.

In this case the injector was running without waste at the overflow, and no water pressure could accumulate by its stoppage; consequently there appears to be no reason why the phenomenon could not have been attributed to the suction of air by the jet into the delivery tube, nor why an increase of pressure might not have been effected in the same way by increasing the water supply.

The injector evidently had not enough water for the steam used, and it took in air whenever the opportunity offered.

The fact, as reported, that the temperature of the delivered water fell from 136° with overflow closed to 127° with it open, some steam being shut off to keep the water pressure constant, is not conclusive proof that "the steam so shut off was undoubtedly saved," as we are led to infer by the presence of the atmospheric air.

It is highly probable that the temperature of the delivered water could have been reduced in the same way with the overflow closed, and it is to be regretted that after the instrument had been adjusted to the water pressure of 83 pounds, with overflow open, that the temperature and pressure of the delivered water was not again taken with the overflow closed. In fact, the fallacy of the above assertion can be shown by Experiment *A* itself; for, as we see, the temperature of the delivered water was 138° with overflow open and only 136° with overflow closed; hence, more water must have been passing through the injector when the overflow was closed than when it was open; and yet, as we see further, 10 pounds more resistance was offered by the globe valve in the delivery pipe to the passage of the smaller quantity of water. The conculsion is inevitable that something besides water was taken in by the jet, and this must have been the air admitted through the overflow.

With regard to the experiments themselves, and the calculated columns in the tables, but one objection, of minor importance, can be made, while great praise should be accorded for the manifest care and labor on the part of the committee in their preparation.

The objection made is to the method of computing the percentage of error given in column 20. By reference to the report the following expression will be found

$$(1 + X)\,D - X\,F = R + E, \qquad \text{in which}$$

R = the total heat of 1 pound of steam for the observed pressure taken from Regnault's tables.

D = the specific heat of the delivered water for the observed temperature.

X = the weight of feed-water delivered per pound of steam.

F = the specific heat of the feed-water for its observed temperature.

E = error of the experiment.

The objection is made on the ground that the total heat of steam as given in Regnault's tables is measured from an arbitrary zero, 32°F., which, while it does not affect the value of E, has, nevertheless, considerable influence upon the value of the expression $(1 + X)\,D$, which forms the denominator of the fraction in computing the percentage.

It would seem logically more correct to determine the percentage of error from a comparison of the calculated and actual quantities of steam used, and this would then give a definite amount independent of any assumed zero of temperature. For instance, in the first experiment 7 per cent. is given as the percentage of error, and we also have from the table:

Weight of feed-water lifted, . . = 471·5 lbs.
Temperature of feed-water, . . = 62·5°
" " delivered water, . = 104·°
Increased temperature of feed-water, . . = 41·5°
Thermal units abstracted from steam, 41·5 × 471·5, = 19567·
Thermal units in 1 pound of steam above 104° from Regnault, . . . = 1086·

The theoretical weight of steam condensed would therefore be $\frac{19567}{1086}$ or about 18 pounds.

The observed weight of condensed steam was 20·5 pounds, a difference of 2·5 pounds.

This difference may be due to priming, radiation, or to errors in observation, but the error of the experiment as deduced from it will be $\frac{2\cdot5}{20\cdot5}$, or about 12 per cent.

It is hoped, in closing this review, that the suggestions and theories advanced may lead to a more thorough and scientific study of the subject than can be derived from experiments designed to show the performance rather than to determine precisely the causes which limit and control the action of injectors.

EYE-MEMORY.

A Lecture delivered before the Franklin Institute March 29th, 1880.

By Charles G. Leland.

(Continued from page 336.)

The writers on the Kindergarten, and on object-teaching in connection with elementary drawing, have hit on a great truth in their endeavor to teach children to form *definite* impressions. But I doubt if any of them, or any one living, knows how indefinite all our memories of objects are, compared to what they might be. Object-teaching causes children to learn the appearance, names and qualities of things. "And many persons," says Mrs. Horace Mann, "object to it because it is playing with things, and the opposite of study." The cultivation of eye-memory must, however, be admitted by the greatest enemy to all new ideas in education, to combine all the discipline of intense study with all that is useful in object-teaching. It is the very opposite to anything like loose thinking or vagueness. It calls for the closest observation and the greatest exercise of the memory conceivable. Therefore it is good discipline for the mind, therefore it should be a legitimate branch of education. But be it observed that this practice of the visual memory, while requiring intense application and much practice, is not disagreeable in the sense in which much study is disagreeable. In fact it cannot be pursued with profit an instant after it becomes wearying. As soon as you tire of it, then, in the words of Westwood, "the visions flee and the dreams depart." The memory will only work of her own accord at this; she will only remain as a willing guest. Force her, and she flies.

On the other hand, *success* in the practice of visual memory is so encouraging that after we once realize our progress the most strenuous effort becomes in fact a voluntary pleasure. I conceive that for its cultivation classes should be formed, at which maps, pictures or any objects being shown for a minute, or for several minutes, those assembled shall endeavor to impress what is set forth on the memory. Now the difficulty at the very outset will be that many of those present, instead of literally getting the object *by eye*, and making the exertion necessary in the beginning will—perhaps unconsciously—make up their minds at a glance as to what the object is, and then in their description or depicting make a clever enough superficial account. These are the ones who, in drawing from a model, look at it a thousand times, carelessly, and yet lose half of what they had gathered in every glance, and make it up by drawing as they think it ought to be—not as they have actually *seen* it. Strictly honest work, and a desire to improve keenness of observation and accuracy of memory, will soon remedy this defect.

I attach great value to bold outline drawings, such as are used in primary classes, as introductory subjects for such study. These, by their simplicity and the striking contrast between white and black which they present, make an impression which is easily retained by an effort of the will. If this impression be recalled frequently during a week, and occasionally revived by study of the original, it will become permanent. Two things are to be observed in connection with this *first* study. Firstly, it is of the greatest importance that it be accurately and correctly conceived, since every error of method which you introduce into it will probably be repeated in the second trial and grow in strength with every successive effort. It is the first notes of the birdling which are almost unchangeable. Secondly, that the more thoroughly it is effected the easier will the next experiment be. It is not advisable that there should be any straining to learn the object in a hurry. Your mind may possibly be involuntarily distracted by some other cause. Your physique may be slightly disorganized. You may be constitutionally of the disposition which requires many gentle and gradual repetitions to impress anything on your memory. Hasten slowly.

Practice in anything makes perfect. From outline drawings you may proceed to objects, from simple objects to statues and the human figure. I have spoken of people who can recall a piece of music, who can literally see in the mind's eye every note, and play from it. I have also mentioned the clergyman who learned his sermons by eye. I think that this might be effected by beginning with a single line, let us say a text or a proverb, very legibly written in bold, thick letters, at least an inch in length, and, in learning them perfectly by eye, care being taken that the imagination shall have no part in re-writing them on the memory. The number of lines may be increased and their size diminished as the power of acquisition is developed.

We all know that, in some way, this power of recalling objects vividly is latent in us. We read familiar books in our dreams, we see the departed, we recall past scenes in reveries, we sometimes imagine faces and remember them after waking. In fevers and in similar states of nervous excitement we think that we see phantoms mingling with real objects. What we thus create involuntarily, in an unhealthy condition, we can also produce healthily, and subject to the laws of reason, by voluntary action. In these dreams, scenes are recalled by association. I have already said that the awaking in our memory of every detail of a scene connected with some startling incident is a fertile theme with novelists. I shall never forget the wonderful, the magnificent sunset which followed the burial of Washington Irving. The western sky, like a vast sea of golden fire, in which were islands of a deeper crimson glow, as though Heaven had thrown its glorious gates ajar to welcome the ascending soul, will always be impressed on my memory. I have doubtless in my time seen sunsets as beautiful in the Far West on the prairies; on the plains of Russia, or in Egypt; but I cannot remember any of them as I do that one on the Hudson.

It may, perhaps, be thought that as all of this is so generally the result of involuntary action, there is no connection to be established between it and the will. Those who would understand this problem, so far as it has in all probability been solved, may read what Carpenter has said in his *Mental Physiology* of primarily and secondarily automatic motion. What I assert is that the will can stimulate involuntary or automatic motion. Did it never happen to you that you cannot recall a certain tune until you by an exertion remembered the *place* where you heard it, or the person who played it? Sometimes, in order to remember a certain remark, you must first recall the time of year when you heard it, then the city in which you were, then the house in which you dined, and finally the person who was seated by you who made the remark. All of these preliminary steps are recalled by deliberate, voluntary action. It is not necessary to enter into a metaphysical analysis of theories of free will and causation. You will probably admit that we can revive, in a more or less perfect form, when we choose, that which we remember, and that the vividness of these memories can be increased by practice.

The practice of eye-memory stores the mind with beautiful images, and increases our artistic sense. It may developed so as to place at our disposal galleries of pictures and statues, scenes in the opera, landscapes or picturesque bits, the forms and faces of friends, or, in fact, whatever we have seen. It may be denied by many that such a power exists in us to such a degree, but I venture to assert that, among all who are present, there is probably not one who has done his best to develop it. For there is no mental faculty, involving so much which is useful or curious, which has received so little attention.

I will now enter upon an abstruse and yet very practical phase of eye-memory, which is also closely analyzed by Carpenter and Clarke. Robert Houdin, in his *Autobiography*, carefully explains that whilst performing his Second Sight he always practiced a *double-consciousness*. That is to say, while performing his trick, he, at the same time, kept in mind the objects which he had *memorized*. In fact, he lays much greater stress upon this double, or simultaneous, action of the mind, than upon the extraordinary feat of getting thousands of objects by heart. Every juggler will understand this. Every juggler knows what "working" means. It means, while substituting an object, or effecting "hanky-panky" by *manipulation* (which requires the shrewdest mental action), to divert the attention of the audience at the same time in another direction. Should he even tell you that at exactly nine o'clock he would pick up a rabbit, with his right hand, from behind a screen, and put it into a hat before the audience you would not see him do it. Because at that very instant he would raise his left hand and snap his fingers in the air, or point to something. If there were a thousand persons present, every eye would be caught and drawn away by the left hand, and during that instant the rabbit would be taken out and put in the hat and nobody present would see it. To do this, the juggler must exert a double action of the mind. The simplest form of this is seen in the child's trick of rubbing one hand up and down on the chest, while you pat your head with the other. Robert Houdin illustrates this by telling us that while obliged to study law in his youth, he, while reading, used to keep tossing four balls in the air.

Now, there is certainly the same double action of the mind while drawing. It requires thought to observe the model, or to form the ideal in the mind, and it also requires thought to perform the action of drawing. You cannot get over this by saying that the drawing becomes merely mechanical. While I have been writing this lecture I have thought of the formation of every letter while I wrote. There are people who are said to write mechanically, but I cannot. Should I do so my writing would be illegible, even to myself. You would say, perhaps, that to do two things at once must detract something from both. I find, invariably, that the more I think about something else, the more carefully I write. Ladies say that they can sew best while talking. I have heard of an actress who was never so thrilling in her tones, never so heartrending, as while embracing her rival; she was at the same time pinching her. This was also a double action of mind. There used to be something of the same kind when I was at college, among the young gentlemen who read novels in chapel during sermon-time. Yet, on reflection, I doubt if in this instance the mental action was exactly balanced.

I have met in my life with two instances of sculptors, both Frenchmen, who required but a single glance at any man to be able to model a perfect likeness of him. One of these artists, M. Garbielli, once took an admirable and very expressive portrait of James Gordon Bennett, whom he had seen only once, as the original went by rapidly in a carriage. A very curious instance of the length of time during which a picture may remain accurately impressed on the memory, is shown in a feat performed by Mr. John Sartain, well known as one of the ablest advancers of art in Philadelphia. Thirty-five years ago, when the old Academy of Fine Arts, in Chesnut street, was burned, there perished in the fire a very valuable picture by Murillo, entitled The Roman Daughter. Very recently Mr. Sartain has drawn it from memory. And Dr. Abercrombie tells us that in the church of St. Peter, in Cologne, the altar-piece is a fine picture by Rubens. This was carried away by the French in 1805, but a local painter made from memory a copy which seems to be absolutely perfect. The original has been restored, and the copy is preserved along with it, and even when rigidly compared it is impossible to distinguish one from the other.

There is in this city a gentleman named John Ryder, a Jessup student at the Academy of Natural Sciences. I am told that he has the power of instantaneous observation, and of subsequently copying, to a degree which far transcends anything I have as yet heard of. Thus, having seen but for an instant any of the rapidly moving animalcules in any medium, through a microscope, he will produce a perfect likeness of it, admirably colored and shaded. I am under obligation to Mr. D. S. Holman, the Actuary of the Franklin Institute, for this curious and valuable illustration of the advantages of eye-memory. And since recording this instance I learn that Dr. Joseph Leidy, of Philadelphia, possesses the same power to as great a degree.

One of the first physicians in Baltimore has informed me that there is in that city, a patient of his, a gentleman who possesses eye-memory to a degree far transcending anything of the kind on record. He can recall, it is said, visually, entire books which he has read years ago, and remembers anything he reads whenever he exerts the determination to do so at the time of perusal.

I know personally a lady, Mrs. Eleanor Meredith, a teacher in Philadelphia, who at one time, in consequence of illness, lost her mental memory. In order to restore it, she practiced getting poetry by heart, beginning with a poem of Longfellow's of about 300 lines. She could not learn it as she wished, but the result of strenuous effort was its visual acquisition, every line and mark becoming visible at will. After a time the lady's mental memory returned. This case is curious. as indicating an absolute difference between mental and visual memory. I have also met with another lady teacher in the same city, who was induced to turn her attention to art by finding herself possessed, to a remarkable extent, of eye-memory. A certain landscape, which she could recall at will, delighted her so much that she determined to draw it. It was her first effort, and after many trials she succeeded in producing a tolerably good picture. There is a waiter in New York who is much employed at balls to superintend the *guarda roba*. He can identify the owners of five hundred hats in one evening. He does this by associating the face of the wearer with his hat and recalling it by eye-memory. "I put the face under the hat and then I know whose hat it is," he says. I know a hotel clerk who remembers with an accuracy which is literally marvelous every trunk which comes to the hotel. There are in America many hotel keepers who, like the late Mr. Willard, rival Mithridates in their memory of faces.

I learn that in the Art School of Boston the practice of drawing with the model removed, as at St. Petersburg, is followed with happy results. I think that, after what I have said on this subject, that no one who will carefully examine it can doubt that the application of eye-memory to free-hand drawing can have anything but happy results. It must be remembered, however, that it requires patience. The faculty is, so to speak, not only dulled and blunted in us by never having been used, but is changed by having been vigorously developed in other directions. Therefore I trust those who experiment on it will persevere and not be discouraged because the experiments of a few days do not yield marvelous results.

There is a faculty so closely allied to eye-memory as to be effectively identical with it. This is *quick comprehensiveness*, or rapidity of sight with intelligence. It is the art of seeing and understanding objects completely, even when in motion, in less time than the great majority of people take in so doing. Educationally its practice would form the next step beyond that of eye-memory. It has also to a degree been applied in object teaching. Eye-memory stores the memory with phenomena; quick comprehensiveness gives rapidity of perception and of thought. For merely mechanical rapidity of observation, induced by mechanical methods, will awaken mental activity at last, even in very dull minds. I regret to say that almost the only people who appear to thoroughly cultivate this invaluable accomplishment are thieves and detectives. It is usual, in training young sneak thieves, for the preceptor, holding a variety of small objects in one hand, to open and close the hand rapidly, and to require his pupils to ascertain at a glance what he holds. They rapidly attain an amazing cleverness and quickness in such perception. A boy thus trained is sent out, ostensibly to beg. He obtains admission to a kitchen; he may get a glimpse of a drawing-room, and with that glimpse he takes in everything, remembers everything, and returning reports what he has seen. There are other people, *not* thieves, who develop the same faculty in observing what is none of their business. They pry and "snoop" about, to use an admirable New York word, which exactly expresses such observation, and go home with what they have got to gossip it. This power of *unusual* quickness of perception, seldom acquired by honorable practices, is generally transmitted to children. It becomes hereditary, and may then be honorably applied. I have had much experience of gypsies, and have observed among them a great development of this faculty. Those petty swindlers who go into shops and practice what is called ringing the changes, or cheating in making change, also develop remarkable quickness of perception. Italians are supposed to acquire it by playing *morra*. Civilization and ordinary education rather repress this faculty than develop it. It is to be regretted that an accomplishment which is capable of contributing so much to our general intelligence, and to the exercise of all our intellectual faculties, should really be deliberately cultivated in its purity chiefly by the vicious and the mean.

On the other hand, the detectives who hunt these foxes are obliged to become almost as clever. Many years ago Chief Marshal Stevens, of New York, told me that he wished to ascertain the character of a man who occupied a certain room which was always kept carefully closed against all intruders. One day he knocked, and the door was opened a few inches for an instant. During that instant his keen eye took in all the contents of the room. He saw that it was hung all round with suits of clothes of a very varied description; he knew at once that they were used for disguise, and observed that some of these disguises were the same as those which had been worn by the man whom he "wanted." One of the most intelligent men whom I have ever known is Robert Walker, Inspector of Police in London. He says that most people, as they walk along a street, look habitually chiefly to the right hand, and that newly enlisted policemen are trained to overcome this habit and look to both sides, so as to become generally observant.

I have spoken of the fact that children receive and retain visual impressions better than grown people. I certainly should not omit to state that Mr. Francis Galton has remarked that women are endowed with this faculty to a much greater degree than men. This great observer has remarked, in *Nature*, that women are not only better gifted than men with what he calls "mental imagery," but that they surpass us in the readiness with which they appreciate the scope and sense of inquiry into it. He says: "I have been astonished to find how superior women usually are to men in the vividness of their mental imagery, and in their powers of introspection. Though I have admirable returns from many men, I have frequently found others, even of the highest general ability, quite unable for some time to take in the meaning of such questions as these: 'Think of some definite object, say your breakfast table, as you sat down to it this morning, and consider carefully the picture that rises before your mind's eye. Is the image dim or fairly clear? Is its brightness comparable to that of the actual scene? Are the objects sharply defined? Are the colors quite distinct and natural?' etc. On the other hand, I find the attention of women, especially women of ability, to be instantly aroused by these inquiries. They eagerly and carefully address themselves to consider their modes of thought, they put pertinent questions, they suggest tests, they express themselves in well-weighed language and with happy turns of expression, and they are evidently masters of the art of introspection. I do not find any particular tendency to exaggeration in this matter either among women or men; the only difference I have observed between them is that the former usually show an unexpected amount of intelligence, while many of the latter are as unexpectedly obtuse. The mental difference between the two sexes seems wider in the vividness of their mental imagery and the power of introspecting it than in respect to any other combination of mental faculties of which I can think."

After such a compliment from such a man it would be indeed ungrateful should the ladies who may meet with these remarks neglect the subject.

As summary and conclusion, I would remark that the development of eye-memory, to a greater or less extent, is within the power of almost everybody. No accomplishment affords such lasting pleasure, and it costs nothing. It can be exercised at any odd time without any preparation. In acquiring it stick to one subject until you can recall every detail of its shape and color. Remember that with young people the development of *quick observation* in a merely mechanical manner leads invariably to mental and intellectual quickness of perception. This wonderful fact, except as far as it has been developed by object teachers, is as yet entirely ignored in education, except by thieves and gypsies. A quick eye develops a quick mind, and a quick eye may be developed by training. And I trust that, from what I have said, you will agree with me that eye-memory, though it is as yet little studied, is destined to exert, at no distant day, a great influence on art and on education.*

Malleable Bronze.—P. Dronier, in Paris, makes alloys of copper and tin malleable by adding from $\frac{1}{2}$ per cent. to 2 per cent. quicksilver. —*Dingler's Journal.* C.

(*As I desire to fully investigate the subject, I would regard it as a great favor if any person who knows of any authentic instance of eye-memory would send me an account of it, addressed to the care of the Secretary of the Franklin Institute. Since this lecture was written I have received a communication from Mr. Francis Galton, in which he requests me to collect such instances in America, with a view to statistical comparison. C. G. LELAND.)

NODAL ESTIMATION OF THE VELOCITY OF LIGHT.

By PLINY EARLE CHASE, LL.D.
Professor of Philosophy in Haverford College.

(Read before the American Philosophical Society, March 19, 1880.)

The accuracy of my approximation to the apparent semi-diameter of the Sun* is confirmed by the following kinetic considerations, some of which, though seemingly of great fundamental importance and character, have been generally overlooked.

1. Matter has been usually regarded as composed of discrete particles. This hypothesis enters even into the kinetic theory of gases. If it is true, all force must be transmitted from particle to particle, and time must, therefore, be required to overcome the inertia of masses.

2. Attraction and repulsion have been generally considered under the influence of central forces, varying inversely as the squares of the distances from the centres and, therefore, producing motions with variable velocity.

3. Waves, orbital undulations, and other cyclical motions, are generally propagated with uniform or nearly uniform velocity, although they are often accompanied by subordinate movements with varying velocity. Variable velocities are often converted into uniform or nearly uniform velocities, as in the case of conical pendulums, planetary rotations and orbital revolutions.

4. In all undulations, and in all cyclical motions through an undulating medium, there are tendencies to synchronism. The synchronism may be complete, producing equal cyclical motions in equal cyclical times, or nodal, producing harmonic series of cyclical motions which are completed in equal times.

5. Newton showed that if a centripetal force varies as the distance of a body from the centre, all bodies, revolving in any planes whatsoever, will describe ellipses and complete their revolutions in equal times;† that bodies which move in right lines, running backwards and forwards alternately, will complete their several periods of going and returning in the same times;† and that if a fluid be composed of

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* *Proceed. Am. Phil. Soc.*, xviii, 380.

† *Principia*, B. I, Prop. 47.

particles mutually repelling each other, and if the density varies as the compression, the centrifugal forces of the particles will be reciprocally proportional to the distances of their centres,[*] as if indicating a reaction against a force which varies as the distance from the centre. The centripetal force is partially illustrated by the rotation of planetary bodies; the centrifugal, by the varying pressure of elastic atmospheres.

6. Such centripetal force as is above supposed requires, for its complete manifestation, an omnipresence of activity, which is devoid of inertia, of ponderability, and of all other ordinary tests of material nature; an activity which may, perhaps, properly be regarded as spiritual.

7. Laplace found himself obliged to recognize an activity in gravitation, which is propagated with at least 100,000,000 times the velocity of light.[†] This activity, he says, may be properly regarded as instantaneous. If it is spiritual, it may without difficulty be regarded as absolutely instantaneous throughout the universe. If it is material, it is difficult to conceive of any relation of elasticity to density which would be so great as 10,000,000,000,000,000 times that of the supposed luminiferous æther. Yet such are the requirements of the Newtonian law, that "the velocities of pulses propagated in an elastic fluid are in a ratio compounded of the subduplicate ratio of the elastic force directly, and the subduplicate ratio of the density inversely."[‡] The importance of this law has been shown by the investigations of Graham, by the inquiries of English and German physicists into the relations between electro-magnetic and luminous velocities, and by my own correlations of the force of solar rotation with the forces of light, gravitation and chemical attraction.

8. In any elastic or quasi-elastic medium, "if the distances be taken in harmonic [or arithmetical] progression, the densities of the medium at those distances will be in a geometrical progression."[§] I use the term "quasi-elastic," in order to meet the views of Faraday, Preston[||]

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[*] *Ibid.*, B. II, Prop. 23.

[†] *Mec. Cel.*, X, vii, 22.

[‡] *Principia*, B. II, P. 48.

[§] *Ibid.*, B. II, P. 22.

[||] *P. Mag.*, June, Sept., 1877. Preston does not give Maxwell's demonstration of the ratio $\sqrt{\frac{5}{9}}$, and neither he nor Maxwell seems to have been aware that I had used and others, who prefer to treat all kinetic questions in accordance with lines of force.

9. The distances of projection, under uniform resistance, are proportioned to the living forces of projection, and inversely as the density of the resisting medium.

10. In most, if not in all, physical investigations which introduce consideration of central force, velocity may be treated as a function of radius, time and mass.

$$v = F(r, t, m).$$

In undertaking to investigate successive conversions of spiritual, undulatory and centripetal or centrifugal energy, astronomical phenomena furnish the most abundant, extensive and varied opportunities for observation and illustration. Unfortunately, there is so much uncertainty in regard to the dimensions and densities of the principal heavenly bodies that we can point to few results which are so precise as would be desirable. There are, however, some important indications of the operation of the foregoing laws, which are confirmed by terrestrial phenomena that are capable of very accurate measurement.

In Searle's *Outlines of Astronomy*, page 403, the following figures are quoted from the *Annalen der Sternwarte in Leiden*, on the authority of Kaiser. "The apparent diameter of Mercury, at a distance equal to the semi-axis major of Earth's orbit, ranges, according to different observers, from 5·2″ to 6·9″; that of Venus from 16·6″ to 17·9″; the apparent equatorial diameter of Mars from 9·6″ to 9·2″; its apparent polar diameter from 9·4″ to 9·2″. Similar disagreements appear in different estimates of the apparent diameters of Jupiter, Saturn, Uranus and Neptune, at a distance for each planet equal to the semi-axis major of its orbit. Thus the equatorial diameter of Jupiter ranges from 39·5″ to 37·1″; its polar diameter from 37·9″ to 35·1″; the equatorial diameter of Saturn from 18·5″ to 16·9″; its polar diameter from 16·8″ to 15·1″; the diameter of Uranus from 2·9″ to 3·6″; that of Neptune from 2·5″ to 4·4″.

Kaiser adopts, as most probable values for the ratios of the several

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the same ratio of *vis viva* five years previously, in discussing results of gaseous energy (*Proc. Am. Phil. Soc.*, Feb. 16, 1872, vol. xii, p. 394, foot-note). I showed that in the explosion of gases, the secondary centre of oscillation, on the return towards the centre, is at $\left(\frac{12}{18} - \frac{2}{3} \text{ of } \frac{12-9}{18} = \frac{5}{9}\right)$ of the extreme excursion.

diameters to Earth's diameter, figures which I have increased by one per cent., in order to adapt them to more recent estimates of Sun's distance. These increased figures are given under r(I), in the following table. Under r(II) and in the subsequent columns, I give theoretical values which illustrate simple harmonic deductions from the above general function of velocity.

	Mass-denominator.	r(I).	r(II).	ρ.		g.	δ.
1. Mercury,	4865751	·34	·36	·387	$\rho^{\frac{2}{3}}$	= ·53	1·484
2. Venus,	427240	·97	·98	·723	$\rho^{\frac{2}{3}}$	= ·81	·822
3. Earth,	330985	1·00	1·00	1·000		1·00	1·000
4. Mars,	3093500	·53	·53	1·524	$\frac{1}{4}\rho$	= ·38	·719
5. Jupiter,	1047·88	11·04	11·02	5·203	$\frac{1}{2}\rho$	= 2·60	·236
6. Saturn,	3501·6	9·10	9·20	9·539	$\rho \div \rho^1$	= 1·12	·121
7. Uranus,	22600	3·60	3·60	19·184	$\rho \div t$	= 1·13	·314
8. Neptune,	19380	5·80	5·84	30·034		·50	·086
9. Sun,	1	109·11	109·05			27·83	·255

The value which I have assumed for Earth's mass is the one which I have deduced from velocities of rotation and revolution and Struve's constant of aberration. The other mass-denominators are the ones which are now generally adopted by astronomers. The semi-axes major are represented by ρ; the superficial equatorial acceleration of gravity by g; the density by δ; Earth's values being assumed as the units. In the expressions for g of Saturn and Uranus, $\rho_1 = 8·539$; $t = 16·9823$; ρ_1 being the mean distance between the centre of the belt of greatest condensation (Earth) and the primitive centre of rotary inertia (Saturn); t being the ratio between the time of Earth's rotation (a sidereal day) and the limiting time of satellite-revolution $\left(2\pi\sqrt{\frac{r}{g}}, \text{ at Earth's equatorial surface}\right)$. It is impossible, at present, to assign any more probable values for the planetary radii than those which I have given under r(II). From those values and the masses, g and δ are readily found by the proportionalities, $\delta \propto m \div r^3$; $g \propto m \div r^2$. The relations of g to simple functions of the semi-axis major would be very striking, even if they were only approximately true. Although we cannot ascertain whether the relations are exact or not, the following considerations seem to increase the probability that they are correct indications of normal harmonic modifications of gravitating force by distance and time.

In comparing the gravitating force at the principal centres of early nebular activity, we may, then, acknowledge a strong probability:

1. That the force at the centre of reciprocity (Neptune) is one-half as great as at the centre of the belt of greatest density (Earth).

2. That the force at the centre of rotary inertia (Saturn) is to the force at the centre of density as the rotary centripetal force at Sun is to the rotary centripetal force at Earth, the rotating tendencies being referred to Saturn as a centre.

3. That the force at the centre of nebulosity (Jupiter) is to the force at the centre of density as the combined influence of the gravitating force at the centre of reciprocity and the rotary centripetal force at Jupiter is to the combined influence of the corresponding forces at Earth.

4. That the force at the centre of nucleation (Sun) is equal to the velocity of light divided by the time of a half-rotation, the half rotation indicating the alternate oscillation of equatorial particles, from and towards the centre of gravity of Sun and Jupiter.

In extending the comparison to the subordinate centres within the belt of greatest condensation, we find a like probability:

5. That the force at Mars is to the force at the centre of density as the combined force of gravitating *vis viva* at the centre of reciprocity and rotary centripetal force at Mars is to the corresponding combined influences at Earth.

6. That the force at each of the inferior planets (Venus and Mercury) is represented by the ratio of projectile living forces to times of revolution.

Leaving the outer and somewhat doubtful territory and entering upon surer ground, let us consider some of the obvious results of conversion of primitive force with reference to centres of condensation.

1. If the velocity is constant, the radius of rotation or revolution must be proportioned to the time.

2. If radii, which were originally established by a constant velocity, are converted into radii of free revolution under equivalent central forces, the times of revolution must be proportioned to the $\frac{3}{2}$ power of the radii.

3. If radii of synchronous revolution and axial rotation are due to the action of a primitive constant wave-velocity, while nucleal radii are due to the collision of particles moving with parabolic velocity, the

former velocity would be communicated in the time of a half-rotation, while the latter would be communicated in $\frac{\sqrt{2}}{\pi}$ of the same time.

4. Let us suppose that the ratio of the solar year to the terrestrial day originated in the constant velocity (1) of light, which is still represented by the equation of solar half-rotation $\left(\frac{gt}{2} = v_\lambda\right)$; that the time-radii ($r_t$) were converted into radii of free revolution under equivalent central forces (2), and that corresponding nucleal radii (ρ_t) were established by parabolic collision (3). We should then have

$$\left(\frac{r_t}{\rho_t}\right)^{\frac{3}{2}} = \frac{\pi}{\sqrt{2}}$$

or, substituting the ratios which are represented by r_t and ρ_t,

$$\left(\frac{1\text{ year}}{1\text{ day}}\right)^{\frac{3}{2}} : \left(\frac{\text{Earth's semi-axis major}}{\text{Sun's semi-diameter.}}\right)^{\frac{3}{2}} :: \pi : \sqrt{2},$$

The sidereal year is composed of the original nebular sidereal rotation and the 365·25636 additional sidereal rotations which are due to terrestrial condensation. Making these substitutions,

$$\left.\begin{array}{l}(365{\cdot}25636)^{\frac{3}{2}} : x^{\frac{3}{2}} :: \pi : \sqrt{2} \\ x = 214{\cdot}5365\end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad A.$$

Among the obvious nodal influences of distance and velocity which may be reasonably supposed to have modified the kinetic undulations between the centres of density and of nucleation, the following may be specified:

1. The velocity of light, V_λ, or the projectile velocity which is equal to the sum of Sun's gravitating equatorial reactions during a half-rotation, $\frac{gt}{2}$.

2. Sun's limiting velocity of revolution, $V_0 = \sqrt{gr}$, r being the equatorial radius.

3. Earth's limiting velocity of revolution, $v_0 = \sqrt{gr}$, at the equatorial surface.

4. Earth's superficial equatorial velocity of rotation, v_r.

5. Earth's semi-axis major, ρ_0.

6. Earth's diameter, $2r$, or the major-axis of limiting synchronous linear, elliptical and circular oscillation.

7. Moon's semi-axis major, ρ_1.

8. The ratio of variation between Laplace's limit, r_1, and the nucleal radius, r_0; $r_1 \propto r_0^{\frac{4}{3}}$.

From Struve's constant of aberration, equation A, and other well-known measurements, we find: $V_\lambda = 214{\cdot}5365 r_0 \div 497{\cdot}827 = {\cdot}4309458 r_0$; $V_0 = 214{\cdot}5365^{\frac{3}{2}} \times 2\pi r_0 \div 31558150 = {\cdot}00062564 r_0$; $v_0 = \left(\frac{3962{\cdot}82 \times 32{\cdot}088}{5280}\right)^{\frac{1}{2}} = 4{\cdot}9075$; $v_r = 2\pi \times 3962{\cdot}82 \div 86164 = {\cdot}288974$; $V_\lambda \div V_0 = 688{\cdot}815$; $v_0 \div v_r = 16{\cdot}98237$. The combined nodal action of V_λ, V_0, v_0, v_r, ρ_0 and $2r$ are represented by the equation:

$$\left.\begin{array}{l}
\frac{V_\lambda}{V_0} \div \frac{v_r}{v_0} = \frac{\rho_0}{2r} \\
688{\cdot}815 \times 16{\cdot}98237 = \rho_0 \div 7924{\cdot}64. \\
\rho_0 = 92{,}711{,}850 \text{ miles.} \\
V_\lambda = \rho_0 \div 497{\cdot}827 = 186{,}233 \text{ miles} = 299{,}705 \text{ kilometres.} \\
r_0 = \rho_0 \div 214{\cdot}5365 = 432{,}495 \text{ miles.} \\
\rho_0 \div r = 23{,}395{\cdot}4. \\
\frac{\text{Sun's mass}}{\text{Earth's mass}} = 330{,}997.
\end{array}\right\} \quad B.$$

If we adopt Newcomb's estimates of Sun's diameter, mass and distance (*Popular Astronomy*, p. 528), the nodal value of V_λ would be 185,334 miles; the value, as determined by Struve's constant of aberration, 185,475 miles; the discrepancy being only $\frac{3}{40}$ of one per cent. Michelson's estimate (299·820 km.) is about $\frac{1}{26}$ of one per cent. greater than mine, and about $\frac{4}{9}$ of one per cent. greater than Newcomb's.

Newton's law of the ratio of elastic densities to distances (8), the law of projection under uniform resistance (9), and the ratio of variation between Laplace's limit and the nucleal radius, all are illustrated by the lunar equations:

$$\left.\begin{array}{l}
\frac{v_0}{v_r} \times \frac{32}{9} r = \rho_1 = 60{\cdot}3815 r. \\
\left(\frac{v_0}{v_r}\right)^{\frac{32}{9}} r = \rho_0 \text{ very nearly} = 23{,}622 r.
\end{array}\right\} \quad . \quad . \quad C.$$

J. J. von Littrow's estimate for Moon's semi-axis major, cited by Searle (p. 406), is 60·2778, or about $\frac{17}{100}$ of one per cent. less than the above result. The velocity of light, as deduced from the lunar value of ρ_0, is 188,040 miles, or nearly one per cent. greater than the value found in equation B.

I think no one will be likely to attach much weight to the larger value, but it is interesting on account of its indication of elliptical nebular influence, with a nucleal radius about one per cent. larger than Sun's present radius, and a major-axis about one per cent. larger than Earth's present mean vector-radius. The nebular influence may be inferred from the fact that $\frac{32}{9} = 2 \times \left(\frac{4}{3}\right)^2$.

OF THE ADJUSTMENT OF A QUADRILATERAL IN A TERTIARY SYSTEM OF TRIANGULATION.

By T. W. Wright,
Assistant Engineer U. S. Lake Survey, Detroit, Mich.

In a quadrilateral $ABCD$ the eight single angles at the vertices are equally well measured; required to adjust it so that the sums of the angles of the four triangles into which it is divided by the two diagonals shall each = 180°.

It follows, from ordinary geometry, that if the sums of the angles of three of the triangles = 180°, the sum of the angles of the fourth triangle must = 180°.

Assume the eight measured angles $A_1\ A_8\ B_2 \ldots$ as approximate values, and call $a_1\ a_8\ b_2 \ldots$ the most probable corrections to these values.

Then the equations of condition are

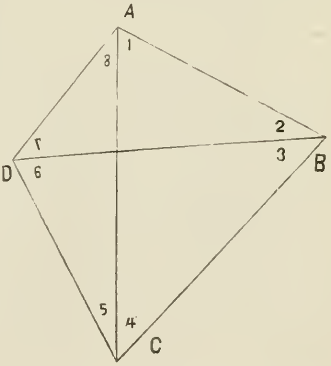
$$A_1+a_1+B_2+b_2+B_3+b_3+C_4+c_4=180$$
$$B_3+b_3+O_4+c_4+C_5+c_5+D_6+d_6=180$$
$$C_5+c_5+D_6+d_6+D_7+d_7+A_8+a_8=180$$

or

$$a_1+b_2+b_3+c_4=v_1$$
$$b_3+c_4+c_5+d_6=v_2$$
$$c_5+d_6+d_7+a_8=v_3$$

with the minimum equation

$$a_1^2+a_8^2+b_2^2+b_3^2+c_4^2+c_5^2+d_6^2+d_7^2=\text{a minimum.}$$



Solving in the usual way we find

$$a_1 = b_2 = \frac{1}{4}e_1 - \frac{1}{4}e_4$$

$$b_3 = c_4 = \frac{1}{4}e_1 + \frac{1}{4}e_4$$

$$c_5 = d_6 = \frac{1}{4}e_3 + \frac{1}{4}e_4$$

$$d_7 = a_8 = \frac{1}{4}e_3 - \frac{1}{4}e_4$$

where

$$e_4 = -\frac{1}{2}e_1 + e_2 - \frac{1}{2}e_3$$

Hence the rule

1. Write the measured angles in order of azimuth in two sets of four, the first being the angles of the triangle *ABC* and the second those of *CDA*.

2. Adjust the angles of each set by $\frac{1}{4}$ of the difference of their sums from 180°, arranging the adjusted angles in two columns, so that the first column will show the angles of *ABD* and the second those of *BCD*.

3. Adjust the first column by $\frac{1}{4}$ of the difference of its sum from 180° and apply the same correction with the opposite sign to the second column.

The final angles will then result.

Example:

		Measured angles.			First adjustment.		Final adjustment.
⊿*ABC*	A_1	32°	05′	40″	39·0″		38·75″
	B_2	74	25	05	04·0		3·75
	B_3	44	12	04		3·0	3·25
	C_4	29	17	15		14·0	14·25
				4			
⊿*CDA*	C_5	22	37	46		46·5	46·75
	D_6	83	52	55		55·5	55·75
	D_7	58	27	42	42·5		42·25
	A_8	15	01	35	35·5		35·25
				58	1·0		00·

APPROXIMATE QUADRATURES OF THE CIRCLE. III.

By Pliny Earle Chase, LL.D.

A late number of *Dingler's Polytechnisches Journal* (March, 1880, pp. 400–1) contains an approximate construction of the ratio of the circumference of a circle to its diameter by L. Hajnis, of Prague. It is not so simple as my first method,* and the result (3·141738) give an excess of ·000146 diam., which involves an error nineteen times as great as that of my first construction, and more than 540 times as great as that of my construction of the ratio of Adrian Metius.†

A previous number of *Dingler's Journal* (1879 **232** 182) gave an approximation which had been simultaneously and independently discovered by Hajnis and by Dr. J. G. Wiedemann, of St. Petersburg. The comparative closeness of the European and American methods is shown below:

		Error.	Ratio of Error.	
1. Wiedemann-Hajnis,	3·141421	—·000171	633	European.
2. Hajnis, . .	3·141738	+·000146	541	
3. Mean of 1 and 2,	3·141579	—·000013	48	
4. Chase, I, . .	3·141585	—·00000766	28·3	American.
5. Perkins, .	3·1415922	—·00000045	1·6	
6. Chase, II, .	3·1415929	+·00000027	1	

Some of the readers of the journal seem to have thought that my second construction was borrowed from Metius. Such is by no means the case. He merely discovered the fractional approximation, and geometers have striven in vain, for 250 years, either to find a simple construction for this approximation or to devise some other construction which would give a result nearly as accurate. All attempts in the first-named direction seem to have been fruitless until I solved the problem; and few of the methods in the second direction, even of those who have thought their solutions rigidly correct, have been so satisfactory as to deserve a place in such a comparison as I have given above. The construction by Perkins was ingenious, and far closer than any which had preceded it, but it was too complicated for any practical purpose. It would be much easier to lay off $\frac{355}{113}$ from a scale of equal parts than to go through all the details of his method, and the result would probably be more satisfactory.

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* This Journal, July, 1879, p. 45. † *Ibid.*, Aug., 1879, p. 105.

For combined simplicity and accuracy sufficient for all practical purposes even my first construction still challenges competition. The second, I think, will long remain an *Ultima Thule* for all who like to amuse themselves with geometrical approximations of this kind.

Since writing the above I have seen a neat and simple approximation by Josef Baader (*Dingler's Journal,* 1880 **236** 258), which gives ·7854004 D^2, the true area of the circle being ·78539816 D^2. The error is, therefore, less than ·0003 of one per cent. This is nearly as close as my first approximation, but the error is more than 30 times as great as that of my second construction.

If the quadrature is desired, instead of the rectification, it may be readily obtained as follows: Referring to the figure (Aug., 1879, p. 105), extend AC to C^1, making $AC^1 = 2\ AC$; on AC^1 take $AF^1 = AF$; join FC^1; draw F^1H parallel to C^1F. Then $AH^2 = {}$·78539823 AF^2.

Chicken Cholera.—Pasteur finds that the germs of chicken cholera increase with marvelous rapidity in a chicken broth, neutralized by potash and rendered sterile by a temperature of from 110° to 115° (230° to 239°F.). If the point of a needle be dipped into a virulent broth the prick of the needle will be fatal to chickens, but it produces merely an abscess in Guinea pigs. The virulence may be diminished by retarding the development of the germs, and inoculation does not then become fatal, but it produces a temporary disorder which, like vaccination, serves as a guard against subsequent attacks.—*Comptes Rendus.* C.

Photography of the Heat Spectrum.—Abney has made a photographic chart of the portion of the solar spectrum which is less refrangible than the line A. It was obtained by a reflecting network, of about 1½ inches opening, and containing 17,200 lines per inch, with a special preparation of silver, which seems sensitive to all radiations. The result agrees with the thermal observations of Lamansky, and also, so far as comparisons have been made, with those of Sir John Herschel. Since the construction of the chart Abney has obtained photographic proofs of solar and artificial spectra which extend beyond the wave-length 19400. A complete description of his processes is to be published by the Royal Society.—*Compt. Rend.* C.

EARLY USE OF ANTHRACITE COAL IN PENNSYLVANIA.

[The following article has been kindly handed to us by Mr. Washington Jones for publication in the JOURNAL. He received it from Mr. John T. Morris, in whose possession it has been, we believe, for a long time. The original writer of the article cannot be discovered at this period, but the ink, faded with time, and the old-fashioned paper attest to the age of the document, which is of great interest if only to show the immense progress that has been made since that time. N.]

In 1824 Jonah and George Thompson, of Philadelphia, made arrangements for the construction of a new steam engine, expressly calculated for the use of anthracite coal, at their iron works on the Schuylkill, 26 miles from Philadelphia; its power was estimated equal to 100 horses.

In January, 1825, it was completed and in successful operation, and no other fuel was used, except small wood for kindling, for upwards of two years that they had possession of the works.

Before their trial they resorted to every means to obtain information whether the coal had been previously used for the purpose either in this or the neighboring States, and the result was that, although many experiments had been made, yet in every instance it had been attended with disappointment and consequently abandoned.

This object (which succeeded on the first trial) was accomplished by dividing the furnaces under the four boilers, of 22 feet each, by a centre wall, making each about 10 feet deep, and having doors at the end; the flues passed into a high chimney in the centre, the draft regulated with a damper, and the grate bars placed much nearer the bottom af the boilers than what is required for other fuel.

The enclosed extract from the West Chester paper, by C. Miner, although the date is not attached, was published without the knowledge of the proprietors:

"We understand that the Messrs. Thompson, at the Phœnix Nail Works, on French Creek, have fully succeeded in constructing a furnace for a steam engine calculated for the use of anthracite coal, and in discovering a mode by which this fuel may be most advantageously applied to that important purpose. We would heartily congratulate the eastern section of our State upon this valuable discovery. Nothing within our knowledge has occurred of recent date which can have a more auspicious influence upon our manufacturing interests. The difficulties which have heretofore been by some supposed insurmountable in the way of using our hard coal for steam engines, have arisen from the intensity of the heat which it gives out in a full state of ignition—its sluggishness in kindling, and the partial suppression of the fire when fresh supplies of coal were added. These difficulties have, as we are assured, been thoroughly conquered by the perseverance and ingenuity of the gentlemen whose names we have taken the liberty to mention. Their success has been complete, and they are therefore entitled to the praise of having conferred upon the community a benefit of incalculable general importance. No one will doubt this who will take the trouble to reflect upon the consequences which have resulted to other countries from the possession of a cheap and abundant fuel for the use of steam engines and other similar purposes. This may emphatically be said to be one of the mainsprings of England's greatness. It is this, too, which has largely contributed to make Pittsburg, which, within the recollection of many a one now living, was but a military station in the western wilderness, one of the first manufacturing towns in our wide spread territory. The same cause, when brought fully into action in our own district, must produce similar effects upon the places within the range of its influence; and especially upon Philadelphia, where mechanical power to any extent, and in almost any situation, can be easily created at a moderate expense. Machinery worked by steam power may be expected to abound among us, thereby producing a consumption of thousands of tons of coal annually. Who can calculate the benefits to result from such a state of things? It will affect the value of our coal lands within a convenient distance from the navigation. It will give constant and profitable employment to a large body of colliers, boatmen and others engaged in mining and transporting the coal. It will secure to the Schuylkill Navigation Company a prolific source of revenue from their tolls. It will encourage and promote the undertaking of similar public works, canals and railroads in the other coal districts with which our State abounds, and especially those which are tributary to Philadelphia. It will open to that city a vast field for the employment of her capital and industry, to the augmentation of her trade and population. These great advantages, so diffusive in their prosperous results, the Schuylkill Navigation will enable us to realize from a sterile and mountainous country, formerly considered almost worthless. Let such considerations stimulate our people to a never-tiring zeal in that cause which should be so near to the heart of every patriotic citizen—the cause of internal improvement."

On the 23d of July, 1829, the writer perfected numerous experiments relative to increasing the blaze of anthracite coal by the introduction of steam into a furnace; it had the effect to a very great extent; but whether the chilling of the furnace will not counterbalance the effect of the increased flame can only be decided by further trials.

The moist blasts in England are now entirely abandoned in the furnaces from the consequent loss of caloric.

Under any circumstances no other difficulty exists in the use of anthracite coal for steam power but its price in comparison with Virginia bituminous coal and wood.

It is understood that the experiment made in Baltimore for introducing steam into the furnace to increase the blaze was in a fire made of bituminous coal and not of anthracite, and the application of it to anthracite and the effects produced was for the first time ascertained in the experiment hereto annexed.

The Messrs. Thompson furnished patterns and information which were applied to the construction of the steam engine used on the Union Canal when the anthracite was employed.

Prediction of Chemical Elements.—In awarding the L. Lacaze prize to Boisbaudran, for the discovery of gallium, the committee remark that the new element was not obtained by accident or by any spectroscopic indications. Its discoverer was led, by theory, to seek, in ores of zinc, an element which was required in order to fill a vacancy in his classification. By operating upon 52 kilogrammes (114·64 lbs.) of blende he succeeded in obtaining one-hundredth of a milligram (·000154 grain) of gallium; in other words, in order to obtain a unit of gallium he was obliged to use five thousand million units of blende. By pursuing his investigations Boisbaudran found that there was a very close agreement between the properties of gallium and those which had been previously announced by Mendelejeff, as belonging to a metal which was required to fill a vacancy in his classification.—*Comptes Rendus.* C.

ON THE ADHESION OF BELTS.

By J. H. Cooper.

The driving power of belts, by which we mean the holding on to, the adhesion, or that which imparts motion to a belt while in contact with a revolving pulley, has been attributed to several causes, to one of which I wish in this short article to refer—that of atmospheric pressure. It is called to mind now by reading some articles in late issues of scientific papers, which lay great stress upon the efficacy of this means of creating adhesion. This announcement is much like that startling physiological statement of the many tons of pressure imposed upon the human body by the atmosphere, which is very taking to the sense until better known.

A belt has a movement to and from a pulley with perfect freedom, regardless of the atmosphere, *touching* it as its form, pliability and strain permit, and *holding* to it according to the interposed unguent, adhesive, or viscous substance, which has been spread over the surface of belt and pulley.

The kind of intermedia used has much to do with the driving power of belts. If fine lubricating oil be employed on clean surfaces of belt and pulley, it will effectually exclude the air from the surface of contact, but the driving power will be reduced to a minimum, if there be any at all transmitted. If dry dust of yielding material be employed on clean surfaces of belt and pulley, then, indeed, will the air with the dust diminish driving power.

There are conditions of belt driving where it is alleged the interposed film of air *lessens* adhesion. Upon this Rankine says: "It is well known through practical experience that a belt for communicating motion between two pulleys requires a greater tension to prevent it from slipping when it runs at a high than at a low speed. Various suppositions have been made to account for this, such as that of the adhesion to the belt of a layer of air, which at a very high speed has not time to escape from between the belt and the pulley. But the real cause is simply the centrifugal force of the belt, which acts against its tension, and therefore slackens its grip of the pulleys."

In collecting "belting facts and figures" during the last score of years, for my own use, I met with several statements asserting with considerable confidence the doctrine of "suction" as the chief cause of attachment between pulley and belt, but I could not find anywhere written a fair statement of reasons why such a force did or did not act according to the circumstances of belt driving, nor could I discover any appeal to experiment, which by removing the atmosphere, putting suction outside the apparatus (as it were), and thus settling once for all the value of vacuum for belt driving.

It is very true that if the belt does not touch the pulley it cannot pull it around, nor can it be driven by the pulley. It is also true that if belt and pulley touch on a limited area only, each can drive the other with a force, but a part of what it is capable of doing, and it is only when contact is made perfect, that is when every square inch of the belt, so to speak, is down solid on the pulley surface, which surface we will grant is very smooth, that the greatest driving effect is obtained.

In practical proof of the necessity of contact and exclusion of air, I offer the accidental discovery of a correspondent of the Boston *Journal of Commerce*, March 5th, 1880:

"Some time since I was running an Andrews pump No. 4, elevating water through a 6-inch pipe 22 feet high, driving the spindle with an 8-inch belt on a pulley 12 inches diameter; 825 Rpm.

"The pulley was on the under side of the belt. I was greatly troubled with slipping and 'squealing' of the belt. Not wishing to run the belt any tighter, I ordered three rows of holes, $\frac{1}{8}$ of an inch diameter, $2\frac{1}{2}$ inches distance on the circumference, to be drilled, preparatory to facing with leather and rivets through the holes. Not being able to finish the job immediately, the belt was put on, and greatly to our surprise worked without slipping or 'squealing' at all, perfectly noiselessly. *The air was let out through the holes.*"

These things being so, are we yet warranted in concluding that the imparting of motion from belt to pulley and pulley to belt is all the work of the air, or, rather, the effect of its absence from the region of contact and the presence of it on opposite sides of belt and pulley?

Again, is the driving of the belt in the same direction as that in which the suction is felt? Now mark, the atmospheric resistance becomes sensible by pulling at *right angles to a plane surface of joint which does not admit air;* release the pull and try to slip the piece used for testing (which may be of wetted leather of handy size) over the surface to which it is applied; it moves freely in every direction, offering no resistance, possessing no adhesion, being, in fact, in equilibrium, and by lifting one edge can be raised wholly away with ease.

The power of the belt does not move in lines at right angles to its contact with the pulley face, but tangent to the pulley circle, parallel to the face of contact; as we slip the *sucker* freely on the flat, wetted surface, so the belt slides on the pulley face, there is no atmospheric pressure manifest in either case.

But has any one tested this matter in a vacuum and made record of the results gained? I have; and if you allow me I will quote from "Use of Belting" what I said about this several years ago:

The adhesion of belts to pulleys is frequently attributed to the pressure of the atmosphere, and in order to show how much the air influences belts in this particular, the following simple experiments are presented:

Take a circular disc of leather, say 3 or 4 inches diameter, with knotted string secured in its centre, and, when well water-soaked, press it upon any level wetted surface. The "boys" call this apparatus a "sucker," and it well illustrates the phenomenon of atmospheric pressure, or "suction," as it is usually called.

If an effort be made to draw it away from this surface by the string, it will be found resisting very forcibly, but the gentlest pressure will slide it on the wetted surface; it does not offer the slightest opposition to motion in the direction of its face, nor will it resist removal if raised first at the edge and then peeled off.

The atmosphere does not press two bodies together when it can get between them; it is only when excluded by a tight joint that the development of its pressure is possible, and it becomes sensible only when an effort is made to separate them by a force acting at right angles to the plane of their faces.

Another simple experiment shows that when two level, smooth and clean surfaces come together by a motion like the closing of a book—which is similar to that of a belt coming in contact with its pulley—there will be retained between the two a thin film of air, and, while this remains, the contact of the two is imperfect, and the sliding of one over the other is easily performed. Take two iron "surface-plates," which have been scraped down to a practically perfect plane, and lay one of these on the other, like a belt goes to a pulley; they will be found not in contact at all, but as if floating one on the other, and the top one will slide off by its own weight at the least inclination of the lower one.

Much of this interposed film of air can be displaced by a sliding of one plate on the other, starting, say at one corner, with the plates in close contact, and carefully pushing one over the other, holding it the while close to, as if to keep the air out. Then, indeed, an obstinate resistance to sliding will be felt, and the friction of nearer contact will be made thoroughly sensible.

But this way of bringing surfaces into contact has nothing to do with belt action, except to prove the need of a plastic surface on belt and pulley, which will enable them to adhere, while in contact, with sufficient force to prevent sliding, and at the same time be uninfluenced by the intermedium of air.

And lastly, in order to put the matter to actual test, an apparatus was constructed, such that a leather belt was made to slide on the face of a smooth iron pulley, and also to drive the same iron pulley up to slipping of the belt. In both cases the adhesion or driving power of the belt was held by a spring balance, so the work of the belt could be observed.

Experiments were tried with this mechanism placed in a bell glass jar on an air pump plate, with and without air in the jar, and if any difference was observed in the adhesion of the belt to the pulley it had more in vacuum than when the atmosphere was present.

Effect of Use upon the Quality of Iron.—In the summer of 1878 Prof. Bauschinger superintended some repairs upon a chain bridge which had been built in 1829. He examined several of the links by various tests, and found that there was no evidence of any diminution in the strength of the iron, nor of any change in its structure or its elasticity during the use of nearly half a century to which it had been subjected. In 1852 von Pauli tested several bars for another bridge, which was repaired in 1878, when Bauschinger subjected some of the same bars to new tests. He found that the mean strength was still the same, after twenty-five years' use, and that no change of structure appeared to have occurred since the time of von Pauli's original tests. —*Dingl. Jour.* C.

The Brush Machine in England.—The competitive trial of dynamo-electric machines by the Franklin Institute has been turned to good account by the proprietors of the Brush machine, who have lately introduced it into England. The correspondent of a French journal states that with 13½ horse-power it maintains 16 lamps, each having a luminous capacity of 1000 standard candles. He pronounces this the most satisfactory result which has yet been attained.—*Chron. Indust.* C.

Yeast vs. Phylloxera.—The recent investigations of Hagen on the destruction of obnoxious insects by application of the yeast fungus have awakened some discussion in the French Academy, in view of the failure of all the plans for destroying the phylloxera. Some members of the commission have recommended the withdrawal of the prize of 300,000 francs ($60,000). The perpetual secretary, however, urged a series of experiments similar to Hagen's, and it has been decided to continue the prize.—*Comptes Rendus.* C.

Fire- and Waterproof Paper.—Mix one-third of ground asbestos fibre with two-thirds of paper paste in a solution of common salt and alum. Pass the mixture into a machine, plunge the paper thus made into a bath of dissolved gum lac and send it through the finishing rolls, when it may be cut into sheets. The salt and alum increase the strength of the paper and its resistance to the action of fire. The lac renders it impermeable to moisture, without interfering with its fitness for the reception of ink.—*Les Mondes.* C.

Chemical Use of Glucose.—According to Böttger there is no method for reducing the salts of silver so convenient and so sure as the use of glucose in alkaline solution. Take, for example, chloride of silver freshly precipitated and well washed, suspend it in a sufficient quantity of diluted caustic soda, and add a small portion of glucose; in a few minutes, upon boiling, the reduction takes place. The silver can be collected, washed and slightly calcined, in order to obtain the metal pure, under the form of a light sponge of a dull white. The same method furnishes an exceedingly active platinum black, and with the salts of copper it gives an oxide of a very beautiful red.—*Chem. Zeit.* C.

Spectrometric Measurement of High Temperatures.—Crova has devised an instrument which he calls *spectropyrometer*. It consists of the combination of a direct-vision spectroscope, a collimator and dispersive prisms, and a graduated circle for determining the degree of rotation which is necessary to equalize the incandescent light with that of a standard lamp. It furnishes the means for accurate measurements, from all temperatures between 580° (1076°F.) and the highest possible temperatures.—*Comptes Rendus.* C.

Spontaneous Generation.—Bastian has again visited Paris in order to try to demonstrate his views with regard to spontaneous generation. Being unable to come to any agreement with Pasteur as to the manner of conducting his experiments, he decided to return to London. But before setting out he described his operation in detail, and Pasteur asked him how he cleansed his retorts. He replied "by rinsing them with very pure water." Pasteur assured him that there were bacteria even in the purest water, and advised him to repeat his experiments after having heated all the apparatus thoroughly in the fire. Nothing has since been heard of spontaneous generation.—*Les Mondes.* C.

Office of Chlorophyll.—By concentrating solar light on vegetable tissue, under a microscope, Pringsheim has conducted a series of "microphotochemic" observations upon the chlorophyll and protoplasmic contents of the living cell. The absorption of oxygen increases with the intensity of the light, and especially with the intensity of the chemical rays. But the increasing intensity of the respiration finally becomes injurious by burning the combustible contents of the cell, and destroying the hypochlorine, which serves as a food for respiration. The light which is necessary for accumulating carbon, therefore, becomes hurtful as soon as oxidation exceeds assimilation. The chlorophyll, by its luminous absorption, helps to balance these two opposite functions. By its preference for the chemical rays it diminishes the respiratory effort, and thus acts as a protecting screen, so that even in the brightest sunlight the assimilation of carbon exceeds the oxidation of the carbonaceous products. Hence, contrary to the prevalent opinion, chlorophyll has no direct relation with the decomposition of carbonic acid, but it serves rather as a regulator of vegetable respiratory action.—*Comptes Rendus.* C.

Wollaston Prize.—The London Geological Society has awarded its great Wollaston medal to M. Daubrée, director of the school of mines, for his researches upon the artificial constitution of the materials found in aerolites and in the lavas ejected from volcanoes.—*Chron. Indust.* C.

Magnetic Rotation by the Atmosphere.—In a work which is not yet completed H. Becquerel has shown how to measure the magnetic rotatory power of certain gases, and especially of the atmosphere, at ordinary temperatures and pressures. He finds that the rotatory power of the air, for the yellow rays, may be represented approximately by 0·090128, the rotatory power of bisulphide of carbon for the *D* line being taken as the unit.—*Ann. de Chim. et de Phys.* C.

Hygiene of the Electric Light.—M. Javal, director of the ophthalmic laboratory at the Sorbonne, has been studying the hygienic influence of the daylight in schools and of various artificial lights upon the eye. He concludes, in accordance with many other competent savants, that the electric light, when suitably arranged, has no injurious influence upon vision, and that it possesses many advantages over the other methods of lighting which are now employed.—*Bull. du Mus. de L'Ind. de Belg.* C.

Compression of Gaseous Mixtures.—If five volumes of carbonic acid and one volume of air are compressed in a proper apparatus the carbonic acid readily liquefies. If the pressure is carried to 150 or 200 atmospheres the meniscus of liquefied acid is gradually effaced, and the liquid finally disappears. The tube then appears filled with a homogeneous matter, which resists all further compression, as a liquid would do. If the pressure is then gradually diminished the liquid suddenly reappears, at a pressure which is constant for fixed temperatures; a thick mist arises, vanishes in a moment, and marks the level of the liquid which has reappeared. The phenomenon cannot be explained by the heat of compression, for the tube is plunged in water which keeps it at a constant temperature, and the compression is made slowly enough for the cooling to be always complete. Cailletet thinks that the gas and liquid are mutually dissolved, so as to form a homogeneous compound. He has extended the experiments to a pressure of 450 atmospheres without varying the result.—*Compt. Rend.* C.

St. Gotthard Tunnel.—The length of the tunnel is 14,920 metres (9·27 miles), the breadth 6·5 metres (7·11 yards). The perforation has required seven years and five months ($4\frac{1}{2}$ years less than Mont Cenis). The average progress per day has been 5·5 metres (5·015 yards). The blasting has used 490,000 kilogrammes (1,302,821 lbs.) of dynamite. The total number of mining holes was about 320,000. There have been 1,650,000 drills, and 1,450,000 cartloads of material have been taken from the interior of the mountain.—*Les Mondes.* C.

Launching a Bridge.—In constructing a railroad bridge over the river Ranee, at Dinard in France, the engineer decided to build the bridge on the shore and then launch it over the river. The bridge weighed, when it was complete, 2,600,000 lbs.; its height above the river was 100 feet, and the span 314 feet. Twelve windlasses were used to draw the bridge into its place. It was supposed that four or five days would be sufficient for the work, but in consequence of the breaking of a chain two weeks were required.—*Der Techniker.* C.

A New Phenomenon of Magnetism.—It is well known that the ratio between the residual and the temporary magnetism of a bar of steel enveloped by a magnetizing coil diminishes as the bar becomes shorter and thicker. Aug. Kighi was led by theoretical considerations to a conclusion which is opposed to the ordinary phenomena, but which experience has confirmed in every particular. It is this: If we take bars of the same steel and of the same diameter, but of diminishing length, we finally reach a length which shows no magnetization, and with still smaller lengths we obtain a residual magnetism which is opposite to that of the coil.—*Comptes Rendus.* C.

Book Notices.

TRUSSES AND ARCHES. By Chas. E. Greene, A. M., Prof. of Civil Engineering, University of Michigan. Part III, Arches. 190 pp. 8vo. John Wiley & Son, New York.

This last part completes Prof. Greene's discussion by graphical and analytical methods of the theory of trusses and arches, and may be said to present by far the most full and compendious text book on this subject yet published.

Throughout the work it is recognized, properly, that the graphical representations are approximate exhibitions of the forces brought into play by supposed constructions, where the relations of lengths of certain lines drawn in certain directions are proved to be, within the limit of desirable accuracy, correct proportions for certain strains in such directions. And this recognition is accompanied by rigorous analytical demonstration, which gives the derivations of such lines and establishes the fact that, with perfect accuracy of drawing, these lines become absolutely correct. It is doubtful, however, if the expressed aim of the author—"to give the ability to intelligently design an arch to those not familiar with higher mathematics"—can be effected. The royal road to knowledge is not shortened by cross cuts. The student or the engineer who shall have so studied Prof. Greene's admirable and *short* treatise as to use it intelligently will have become familiar with the mathematics of the subject. It is possible that in the class in the University a student may be instructed touse the graphical methods independently, but unless the foundation be such that the reason for those methods remain for all time in the memory of the student, his application years afterwards will be likely to be more faulty than that of the wholly uninstructed mechanic who copies admitted excellent practice by a simple effort of visual appreciation, and modifies by empirical proportions to suit novel requirements. The constructor, whether engineer or contractor, who will fully meet a new demand in truss or arch construction will be safe to call to his assistance some one grounded in the elementary knowledge to be found in its best form in this book of Prof. Greene's, and not to trust to an imperfectly understood application of its rules. B.

PRACTICAL KERAMICS FOR STUDENTS. By C. A. Janvier. Square 12mo. New York: Henry Holt & Co., 1880.

In this work the talented authoress has given, in as small a compass as possible, a clear account of the manufacture and decoration of pottery of all kinds, the well known works of Jacquemart, Marryat, Birch and others having been carefully studied beforehand, and while she has devoted most attention to kinds of pottery that have a general interest, histories of it have been omitted, or only touched upon, from having appeared so often before, and illustrations of the machinery used, furnaces, etc., are not given, for the same reason. The fullest details seem to be with regard to modern pottery, Limoges wares and the wonderful productions of the Chinese and Japanese artists, so eagerly sought for by all collectors. In the first chapter the nomenclature of the subject and depositions are given, followed by a brief historical sketch and an account of the materials that enter into this important manufacture. The various processes are then taken up, the preparation of the pastes, the shaping, glazing, firing, etc. An important chapter is then given on the decoration of porcelain. A description of the different wares then follows—soft pottery, hard and very hard—being the general divisions, and the remainder of the work is taken up with a treatise on keramic painting, æsthetic hints, etc. In an appendix we have a short bibliography of the subject (only a few authorities being mentioned), and a brief criticism of their works are given. The index, without which by a heavy penalty in law no book should be allowed to appear, is quite a full one, and admits of ready reference to any particular point.

The work is tastefully got up, and the cover highly artistic and attractive. The paper and the broad margin of the page are in the right direction, but we cannot help but think a lighter-faced type and less heavy impression would have made a more beautiful book. N.

DWELLING HOUSES: Their Sanitary Construction and Arrangements. By Prof. W. H. Corfield. 18mo. New York: D. Van Nostrand, 1880.

The great importance of the subject, and the interest manifested in all that pertains to the hygeine of our homes, was the reason of the republication of these lectures in their present form. After giving some directions as regards the situation and construction of a house that apply to our country as well as England, the important subjects of ventilation, lighting and warming are taken up. The author believes that the use of coal in our houses will cease almost entirely, and the proper use of gas will be found in heating apartments, cooking, etc., stoves for this purpose being highly commended for their convenience and cleanliness, the products of combustion being of course removed. The remainder of the work is taken up with the question of sewerage, ventilation, etc.

The eminence of the author, and his high reputation as a writer, particularly qualify him to speak intelligently on these subjects, and his work is worthy of a careful study by all interested. N.

TIN MINING IN LARUT. By Patrick Doyle, C. E. With maps, plates, etc. 12mo. London: E. & F. N. Spon, 1879.

This little book has been reprinted from the *Mining Journal*, and is the result of notes made during the author's connection with the mines, and data obtained from the most reliable mine owners in Larut, and is accordingly very interesting. The author states that the whole of the land lying along the base of the Larut ranges is more or less stanniferous, and that the strip is in length about fifty miles, with an average breadth of six miles. The tin beds are composed of granitic rocks mixed with the ore, the crystals (peroxide of tin) varying from that of fine sand to the ordinary quartz pebbles. There are eighty mines in operation, owned by forty firms, employing on an average eighty-six men in each mine. As the Chinese are slaves of custom, and everything is done by precedent, they are much averse to improvement; and yet in one of the largest of the mines a centrifugal pump and engine has been introduced in place of the comparatively useless Chinese water wheel, and with admirable results. At present the extensive mining operations in this locality are carried on entirely by the Chinese, the country being an "El Dorado" of mineral wealth.

N.

Franklin Institute.

HALL OF THE INSTITUTE, May 19th, 1880.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 135 members and 29 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that 12 persons were elected members of the Institute at their last meeting. He also announced the award of the Elliott Cresson gold medal to William Farr Goodwin, for his mowing machine, in accordance with the recommendation of the Committee on Science and the Arts.

The Secretary reported the following donations to the Library:

Letter from Secretary of War transmitting Papers of Second Installment to Jas. B. Eads. From the War Department.

Catalogue of Pennsylvania State College of Agriculture. 1879—1880. From Jas. Calder, President.

Circulars of Information of the Bureau of Education. No. 1, 1880. From the Bureau.

Letter of the Commissioner of Agriculture to Hon. J. W. Johnston on Sorgham Sugar. From Agricultural Department.

Annual Report of Friends' Free Library of Germantown. From the Library.

Papers read before the Pi Eta Scientific Society. 1879—1880. From the Society.

Charter and By-Laws of the Pennsylvania Museum and School of Industrial Art. From the Museum.

Measurement of Powder Pressures in Cannon. From Charles Bullock.

Tenth Annual Report of Lake Shore & Michigan Southern R. W. Company. From the Company.

General Systems of Measurement for Urethal, etc., and Researches on Hearing, by C. H. Thomas, M. D. From the Author.

Special Report of New York State Survey on Niagara Falls. From Jas. T. Gardner, Director.

Transactions of the Wisconsin State Agricultural Society. 1873—1879. From George E. Bryant, Secretary.

Twenty-first to Twenty-third Annual Reports of the Secretary of the Board of Agriculture of Maine. From L. S. Ware.

Iron and Steel Works of United States. 1880. From American Iron and Steel Association.

Crosby Steam Engine Indicator. From G. H. Crosby.

Twenty-sixth to Twenty-eighth Annual Reports of the Indiana State Board of Agriculture. From the Board.

Eighth to Tenth Annual Reports of the Geological Survey of Indiana, 1876—1878, by E. T. Coxe. From the Author.

Annual Reports of the Operations of the U. S. Life Saving Service for the year 1879. From the Treasury Department.

Report of the Council of Education upon the Condition of the Public Schools of N. S. W. 1878. From W. Wilkins, Secretary.

Council Books of the Corporation of the Cities of Cork and Kinsale, by R. Caulfield. From the Author.

Annales Industrielle. 1869—1874. Text and Plates.
From L. S. Ware.

Mr. W. Barnet Le Van read a paper on "High Railway Speeds," suggested by the trial trip of the locomotive built at the Baldwin Locomotive Works for the Reading Railroad Company, and intended to run from Philadelphia to New York in 90 minutes, or at the rate of a mile a minute. To do this it must be capable of running at a faster rate on parts of the road to make up for time lost in passing over bridges and through towns, where a slower rate is necessary. To accomplish this with safety the road bed must be in perfect condition, and some changes must be made in the form of locomotives as now commonly used. This new locomotive has a single pair of driving wheels 6½ feet in diameter, in place of coupled drivers of 5½ feet in diameter. In the latter form of engines run at high speed there is danger that the coupling rods connecting the driving wheels will be broken by centrifugal force. The larger wheel also reduces the number of revolutions per mile of run. In the new locomotive the boiler has 1400 square feet of heating surface and about 56 square feet of grate surface. The dimensions are as follows: Diameter of cylinder, 18 inches; length of stroke, 24 inches; diameter of driving wheel, 78 inches; wheel base, 21 feet 1 inch; distance from centre of driving wheel to centre of trailing wheel, 8 feet. The boiler is made of $\frac{7}{16}$ inch steel and is 52 inches in diameter. It contains 198 tubes 2 inches in diameter and 12 feet 2¾ inches long. The fire box is 96½ by 84 inches. The capacity of the tender is about 3,800 gallons of water, and weight when filled with water and coal, 70,000 pounds. The weight of the engine is 85,000, and is so disposed that by an alteration of fulcrum points additional weight can be thrown on the drivers at the time of starting. At a trial trip on May 14th, the engine was attached to a train of four cars, each weighing about 42,000 pounds, making the weight of the train complete, about 148 tons. The run was made at rates ranging from 27 miles an hour, between Ninth and Green and Wayne station, to 63 miles an hour, between Trenton Junction and Bound Brook, the time from Ninth and Green to Jersey City (89.4 miles) being 98 minutes, or at the rate of 54¾ miles per hour. On the return trip the run was made in 100 minutes. In a former trip the engine developed a speed of nearly seventy-nine miles an hour. In these trial trips the engine consumed 36 gallons or 300 pounds of water per minute. Mr. Le Van prophesied that within five years "passengers would be set down in New York in one hour's time from this city." The average time on English railways is 46 miles per hour, on French 37½, on German 40, and on American 37. On English railways, 6½ feet driving wheels are quite as common as 5½ wheels, and some of the fast lines have 8 and 9 feet wheels, one line having 10 feet wheels. Engines with one pair of drivers are not new in this country, and Mr. Le Van described several which had been built at the Baldwin Locomotive Works, by Eward S. Norris and Norris Brothers, and by Ross Winans, of Baltimore. Some of these developed high rates of speed.

At the conclusion of the reading of the paper Mr. J. Snowden Bell said he regretted that Mr. Le Van had not informed the Institute about the grade of the road and the steam pressure during the trial trip. In considering the capacity of engines it is very important to know the grades of the road and the capacity of the engine for generating steam. He spoke of a trip he had made over the line last Monday in a regular train, when the odor of gas from the engine was very strong, and the engine ran with noticeable irregularity.

Mr. Le Van said that the grade, he believed, was about 56 inches to the mile. On the trial trip the steam pressure was 140 pounds at the start ; it ran down to 90, owing to the use for a time of poor fuel, and when the train reached Jersey City it was about 130. On the return trip the engine started with pressure at about 140 and reached Philadelphia with about 120 pounds. He had no doubt that a pressure of 120 pounds would be required for a steady run. He said that he believed this new engine had all the elements of speed.

Prof. Marks said that he had made some calculations of the maximum speed at which engines could be driven before the centrifugal force on the tires of driving wheels would become so great as to cause them to burst. These calculations, which were approximate only, showed that the limit of speed was in the neighborhood of 150 miles an hour, and we have already attained 78 miles an hour, or more than half that limit. He was asked whether there was not danger that the heating effects of such rapid travel would be so great as to destroy the axles and bearings. He replied that Dr. Lardner had published what he considered demonstrations that the heating effects of revolving paddle wheels of steamships would be so great as to burn them up before they could get out of their docks, and in view of the practical refutation given to those "demonstrations" he did not think it worth while to make similar prophecies about the heating effects of high rates of speed on railways.

In reply to an inquiry from the President as to the authority for the statement about Dr. Lardner, Prof. Marks said that an American edition of Lardner's lectures had been published in New York, he thought, in 1832.

A gentleman inquired whether, in view of the increased speed of trains, the trestle work bridges on the Bound Brook route were to be strengthened, saying that, while crossing one of the long bridges recently, the passengers in a train were startled by the vibrating of the bridge.

Mr. Le Van said that, on the trial trip, the day being calm, he had gone out on the platform to notice the effect in crossing the bridges, and there was no unusual vibration or swaying of the structure. He understood, however, that the bridges were to be strengthened and made entirely safe for the running of fast trains.

Mr. R. R. Atchison, of New York, presented samples of work done by his new metal, wood and stone working machinery, and presented a paper descriptive of the uses to which it could be applied. He claimed for the machine a new mechanical movement, the bits (in pairs) with which the work is done having a continuous rotary motion, as well as an alternating percussive stroke. This, he says, gives a new and peculiar cutting action with not only the fast clipping power of the pick or chisel when used by hand with a twisting motion, but the smooth, steady work of a rotary bit. The resistance to feed is much less than with a routing tool, which is always in contact with the work. In the new machines the bits are out of the work more than they are in it. The inventor claims that the wear on tools is considerably less than one-half compared with hand work, and that they can be used constantly on granite for at least one hour without changing. One set will cut not less than 360,000 blows, without requiring to be resharpened—equal to five hours of hand work. A large machine for stone cutting, now in use in New York, dresses blocks of granite eight by five feet on the ground and 3½ feet high, and can be adapted to work larger blocks. The head is given all the various feed motions required for different kinds of work, but, unlike an ordinary pit planer, the head cuts on the return as well as on the out-stroke. The wood-working machines have the same peculiar mechanical movement. They are particularly adapted to carving advertising signs, making pattern blocks for printing, wood blocks for circus and theatrical printing, etc. The metal-working machine is similar to the others, but much smaller, and is already in use for matting and chasing jewelry and silver ware. Several beautiful specimens of the work of the machine were exhibited.

Mr. J. E. Mitchell said he was happy to hear that there was at last a machine that would economically dress such a hard stone as granite, but he desired further information on that point, and inquired what amount of granite could be dressed in an hour.

Mr. Atchison replied that the machine would cut granite at the rate of 9 square feet in 12 minutes $\frac{1}{16}$ of an inch deep.

Mr. Mitchell said that that was not deep enough to dress off a block as it comes from the quarry.

Mr. Atchison said that the operation could be repeated as often as required, and that, if there were great irregularities, the cutters could be employed only in the higher parts, until they were gradually reduced to the general level.

After further inquiries Mr. Mitchell figured out that to remove one inch from 9 square feet of granite would require three hours, and he thought this was not enough to make the machine economical. He then inquired about the tools, and being told that they struck 6000 blows per minute, and could be run for an hour without sharpening, said that they must be made of steel of remarkably fine quality.

Mr. Atchison said that they would not be dulled as quickly while striking 6000 blows per minute as if they were run at slower speed, say 4000 blows per minute.

Mr. Mitchell inquired as to the cost of the machine.

Mr. Atchison said that only one large stone cutting machine had been built, that now in New York. It was the first of its kind, and had cost $3000, but every one who had ever undertaken to build a first machine would understand that duplicates could be made for much less. This machine had been run experimentally for about a year, and on its performances were based the statements he had made as to its capacity.

Specimens of aluminium obtained by a new process, and of its alloys, were exhibited by the Pennsylvania Nickel Works. A paper on the subject stated that, in 1827, Prof. F. Woehler discovered the metallic base of clay—aluminium—and that it was not until 1854 that Henry St. Clair Deville, after many experiments, succeeded at last in gaining the metal in larger quantities, and in introducing it in the metallurgic industries. He reduced chloride of aluminium by heating it with sodium in dry hydrogen gas, and up to the present time his laboratory has been the only source of supply. In 1858, Mr. William Frischmuth, of this city, employing a similar process, gained aluminium, but his labors were financially unproductive, and he abandoned them to raise a regiment during the war. Quite recently, while experimenting with nickel ores, he discovered a more direct method of smelting aluminium, and he exhibited ingots produced by his process. He said that the metal could be obtained cheaply and almost chemically pure, so that it can be extensively used for the manufacture of articles requiring a strong, light metal, such as mathematical, optical and surgical instruments. The color of the metal is white, it polishes like silver, does not tarnish, has the tension of copper, and a specific gravity of 2·65, that is to say, it is four times lighter than silver. Its alloys promise to be particularly useful. With nickel it forms a tractable compound called Alu-ni, which was patented last December to be used for electro-plating. Alloys of aluminium with copper and with iron also promise to be useful in manufactures and for electrical conducting wires. The metal itself is very ductile, and can be drawn into the finest wire. It takes the place of silver in bronzes, because of its lightness and untarnishing qualities. The pure metal and its alloys are manufactured at the Pennsylvania Nickel Works of Frischmuth & Van Tronk.

Prof. Marks exhibited a Peaucellier compound compass, a beautiful piece of workmanship made by Mr. Young, of Philadelphia, and mentioned at the previous meeting as the only machine capable of drawing a straight line. He explained its construction, and said that he desired to convince Mr. Nystrom of the truth of his previous assertion, and to correct his statements as to the Sellers planer being capable of making a straighter line. The machine was afterwards shown at work, and, in the language of Prof. Marks, made a line "straighter than a straight edge." It was not designed, however, for this purpose, but to describe arcs of a radius from a few inches to infinity, and, being so compact, was of great use to draughtsmen and others, and capable of taking the place of immense beam compasses, requiring two men to operate them.

Mr. Nystrom examined the machine critically, and said that he had no doubt it would draw a straight line *if* certain rods or arms were made, according to the design, exactly of the same length; *if* certain other arms were in a fixed proportion to these and exactly equal to each other; *if* the pins on which they worked were exactly true, and *if* they were perfectly fitted; there were not, however, so many ifs in the Sellers Planer, and he maintained his former opinion.

Among the novelties shown were the following:

Mr. Spellier exhibited a new pendulum suspension device, designed to keep the oscillations of the pendulum in a true plane only. This is secured by giving the suspending spring an even tension.

Griscom & Co.'s machine for re-fitting valves, a small hand lathe, with attachments to produce true bevels, could be used to repair valves on pipes or boilers without disconnecting.

Morse's adjustable shelving, a cheap device for supporting shelves and allowing the brackets to be adjusted to any desired height. The brackets fit into a toothed rack, which, being securely fastened vertically, the brackets themselves have simply to be put in place to prepare supports for shelves in stores, kitchens, conservatories, museums, or in any place where it may be desirable to have adjustable shelving.

Rutherford's adjustable horse collar and hames, made of malleable iron and capable of adjustment to fit any horse and to allow a change of draft to suit the work.

A model of A. B. Turner's patent underground telegraph line. The design is to form sections of glass, furnace slag, or other insulated material, to be laid like sections of terra cotta drain pipe, but having, instead of one hole, a number of small holes, each to contain a single uncovered wire; also to have relays, etc., to allow tests of the line and the turning of corners.

Batchelder's Patent Scintillating Gas Lighter, giving 4000 lights with one charging of the apparatus; Crawley & Develin's Shutter Locking and Bowing Fixture; Rogers' Sewing Machine Scissors, with screw-driver, wrench, etc., combined; Peterson's Patent Waterproofing Material, and Howard's Metallic Brushes.

A letter was read from Prof. Henry Morton by the Secretary, stating that, in the examination of the Brush Co.'s Electric Lights at the Coney Island Pier, they were not in charge of the Company, and the results as read at the March meeting* were probably anything but an average performance.

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* See JOURNAL, pp. 284 and 418.

An abstract was also read from a paper concerning the early use of anthracite coal in Pennsylvania.

Prof. Frazer's resolutions with regard to an appointment of a committee of chemists to report on the scientific value of some expert testimony given in a recent trial, came up as deferred business from the last meeting, and was, on motion of Mr. Chabot, again postponed.

Mr. J. W. Nystrom offered the following:

In the May number of the JOURNAL I am recorded to have said that "When a governor, running at a constant speed, can keep it almost closed, it is practically an isochronous governor." It should have been reported: "When a governor, running with a certain constant speed, can keep the throttle-valve of a steam engine wide open, and can also keep the same throttle-valve nearly closed whilst running with the same constant speed, then the governor answers the purpose of isochronous, and is therefore practically so."

I also said that cycloidal pendulums were tried on clocks in Vienna, but not "some years ago," as the minutes make me say. The isochronal properties of the cycloid was discovered by Galileo in the year 1615, and applied to clock pendulums by Huyghens about the year 1655, or 225 years ago. The principle of applying the cycloidal pendulum to clocks is described and illustrated in works on clockmaking, published in the principal languages of Europe in the last century.

The minutes also make me say that the term "isochronous can really be of no practical use," although I expressed my desire to "retain that term for practical use," as there is no other term in the English language which expresses that property of a governor.

The subject was discussed by Messrs. McKean, Eldredge, Burk and others, and on motion the corrections were ordered to be referred to the Committee on Publication, that they might appear in the JOURNAL.

Mr. Hector Orr offered the following resolution:

Resolved, That by the death of MR. JOHN McCLURE our community has lost a valuable citizen and our Institute a model member. That we recall with gratification his long services among us, and while we here record our sincere regret at the deprivation now incurred, we commend his example to all survivors and successors.

On motion, the Institute adjourned.

ISAAC NORRIS, M. D., *Secretary.*

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